
Carnegie Mellon University

Undergraduate Catalog 2015-2016

College of Engineering

The College of Fine Arts

Dietrich College of Humanities and
Social Sciences

H. John Heinz III College

Mellon College of Science

The School of Computer Science

Tepper School of Business

Carnegie Mellon University in Qatar

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Foreword

Foreword

This catalog is intended to detail the University's academic programs, policies and services for use by current undergraduate students, faculty, and administrators. We appreciate that applicants, prospective students, and many other people will read this material, as well, for some understanding of University programs and culture.

Information in the catalog is current as of August 2015; the next Catalog will be published in August 2016. In the interim, new courses will be announced in the course schedules which are usually available in November and April and on the Web (www.cmu.edu/hub).

The program requirements and academic policies set forth in this Catalog are subject to change. As a consequence, students are expected to consult with their individual college or department for the most up-to-date information about program requirements, and should consult the University's policy website for the most current statements of University policy.

Any changes or updated information from any member of the campus community should be directed to John Papinchak, University Registrar.

Michael C. Murphy
Vice President for Campus Affairs

Jonathan D. Samuels, Assistant Registrar for Records & Undergraduate Catalog Editor
John R. Papinchak, University Registrar
Published August 24, 2015

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Frequently Asked Questions

Q: What is the Undergraduate Catalog?

A: The Undergraduate Catalog, published every year, contains information about and academic requirements for each course of study or program available to undergraduate students at Carnegie Mellon, as well as course descriptions and university policies.

Q: For whom is the Undergraduate Catalog relevant?

A: The Undergraduate Catalog is most relevant for students entering in the year of publication. However, returning students should also use the Undergraduate Catalog to look at new programs and courses of study that may interest them.

Q: How often is the Undergraduate Catalog updated?

A: The Undergraduate Catalog is published every year. The next Catalog will be published in August 2016.

Q: The requirements for my major are different here than when I entered Carnegie Mellon; will my classes still count the same towards graduation?

A: Yes. A student's requirements for graduation are determined by the year he or she enters Carnegie Mellon. If a program or major's requirements change in a later catalog, these changes will only affect students entering during that Catalog year.

Note: The only exception is for courses which stop being taught or change course number. You should confer with your academic advisor each semester in order to be sure you are on track for graduation. You can also use the Academic Audit (<https://enr-apps.as.cmu.edu/audit/audit>) tool to check on your progress.

Q: Does the Catalog include course times and locations?

A: No. Current information on course times and locations can be found on Student Information Online (<https://s3.as.cmu.edu/sio>), under the Course Schedule tab.

Look at Carnegie Mellon

Excellence in Practice and Learning for Life

Carnegie Mellon emphasizes a deep connection between theoretical knowledge and practice: the university's interdisciplinary approach to education stresses the practical application and analysis of knowledge in institutional, social and historical contexts. "On a campus of 110 acres, research and teaching are conducted in more than 30 different fields of the arts, humanities, engineering, the sciences, social sciences, management and public policy. Students and faculty in these areas are in daily contact with one another, pursuing interdisciplinary projects, redefining fields of knowledge, pushing their own visions of the possible and contributing to the world around them," writes Jared L. Cohon, the eighth president of Carnegie Mellon in "The Innovative University," a volume of writings that celebrated Carnegie Mellon's centennial in 2000. Carnegie Mellon graduates are excellent practitioners in their chosen fields. The university is in the process of enriching and complementing this education to ensure that our students also gain broader, well-informed perspectives that will help them grow and change with their professions; interact wisely with the natural environment; and be responsible and informed citizens in an increasingly technological world and complex global culture.

From Technical School to International University

In a letter written in 1900, industrialist and philanthropist Andrew Carnegie offered to give the city of Pittsburgh \$1 million in bonds to found a technical institute. The city provided 32 acres of land near Schenley Park, and the institution became known as the Carnegie Technical Schools. According to Carnegie's plans, the institution would train the sons and daughters of working-class families in five schools: Science and Technology, to train draftsmen and engineer's assistants; Fine and Applied Arts, for designers and art workers; Apprentices and Journeymen, for mechanics in manufacturing and construction; and Margaret Morrison Carnegie College, for home economists or secretaries. Within two decades, the Carnegie Technical Schools offered bachelor's, master's and doctor's programs, and fittingly changed its name to the Carnegie Institute of Technology.

In 1967, the trustees of the Mellon Institute and the Carnegie Institute of Technology merged the two institutions and adopted the name Carnegie Mellon University. In 1968, Margaret Morrison Carnegie College closed and the university organized a new College of Humanities and Social Sciences. New graduate-level colleges and schools also flourished, including the Graduate School of Industrial Administration (GSIA), the Heinz College of Public Policy and Management, and the School of Computer Science. As time progressed, new research centers and institutes developed on and off campus in specialties ranging from art conservation to sustainable computing. In 2004, GSIA was renamed the Tepper School of Business after alumnus David A. Tepper.

The Carnegie Institute of Technology has developed from a regional, technical college into Carnegie Mellon University, a selective, international research university that consistently ranks among the nation's best colleges in U.S. News & World Report, Newsweek and BusinessWeek magazines. The university is also a leader in environmental sustainability and energy efficiency, and is home to the nation's first Leadership in Energy and Environmental Design (LEED) certified dormitory. University Business magazine identified Carnegie Mellon as one of the nation's Higher Education Sustainability Stars.

Undergraduate students can pursue majors in six of the university's seven colleges: the Carnegie Institute of Technology (engineering), the College of Fine Arts, the Tepper School's business administration program, the College of Humanities and Social Sciences, the Mellon College of Science, and the School of Computer Science. Carnegie Mellon also has campuses in California and Qatar and is expanding its presence in Europe, Australia and Asia with master's programs and other educational partnerships.

A Unique Educational Experience

The university's diversity, focus on strong student-faculty ties and commitment to education outside the classroom combine to create a learning environment that is as uniquely Carnegie Mellon as the Tartan plaid on the kilts of its bagpipers.

Carnegie Mellon strives for a campus culture that reflects a fundamental respect for different ways of living, working, and learning so every student

has the opportunity to reach her or his potential. The university community is diverse, with roughly 12,000 students, nearly evenly split between undergraduates and graduates, and more than 1,400 faculty members. About 10% of undergraduate students are underrepresented minorities and 17% hail from countries outside the U.S. Faculty and graduate students also come from across the globe.

The university's small student-to-faculty ratio gives students the opportunity for close interaction with their teachers - an essential component of academic success. But while professors spend a great deal of time with students, they also expect them to develop initiative, to critically assess their own progress and to work as teams. Working together, students and faculty create real-world projects with immediate impact. A design professor might critique a student's sketches of a company logo, or a team of students will work with professors and researchers to design an autonomous robot for a race across the desert. Faculty at Carnegie Mellon take an interest in their students' questions and concerns beyond the classroom. Some serve as academic advisors, while others seek undergraduate assistance with research projects or oversee student-proposed projects.

Equally important to the Carnegie Mellon education is the meta-curriculum, the learning that occurs outside classes through community service, interacting and learning in the university's international community, or even just living in the residence halls.

Structure to Succeed, Freedom to Explore

A Carnegie Mellon education is marked by its strong focus on fundamental and versatile problem-solving skills in a specific discipline, but the university respects and values students' varied talents and interests that often span many specialties. At Carnegie Mellon, students can explore more than one field of study while developing the strong professional core that is the hallmark of a Carnegie Mellon education. The university encourages students to expand their thinking in new and exciting dimensions, whether by taking courses from disciplines across the university or pursuing a double major or minor - frequently in a different college. Students can even design their own majors. In a community rich with seven colleges, the academic options are as varied as the students who pursue them.

Though academic interests may differ, the university has structured its programs so students develop skills vital to all professions, with communication and reflective practice acting as the common threads connecting these skills. In order to excel in any field and lead a life of social responsibility and lifelong learning, students must be able to understand the theoretical basis and practical implications of knowledge and action, convey ideas and information effectively, and be reflective practitioners. Carnegie Mellon instills these qualities in students and gives them a wide array of perspective and opportunities by creating an environment of learning-by-doing, providing them with a strong analytical background, and encouraging them to do and make.

Strength in Research and Artistic Creation

At Carnegie Mellon, faculty members aren't just devoted teachers. They conduct groundbreaking research, create new and exciting art, and contribute to a growing global scholastic community. The university's faculty are continuously innovating, and the new knowledge they create and the methods they discover routinely benefit classroom learning. Each college and dozens of special centers focus on issues and developments that affect the world beyond Carnegie Mellon.

Researchers in the Mellon College of Science received a \$13.3 million grant to develop the National Center for Networks and Pathways, which will generate molecular bio-sensors that will change the way scientists look at living cells. A study by researchers in the College of Engineering found that cell phones and other portable electronic devices can interfere with the normal operation of critical electronics on airplanes. Meanwhile, in the university's Dietrich College of Humanities and Social Sciences, faculty have made critical strides toward understanding what causes autism and how it can be treated more effectively. The National Science Foundation funded a new Quality of Life Technology Engineering Research Center — a joint effort of Carnegie Mellon's School of Computer Science and the University of Pittsburgh — that will design and commercialize technology to help older adults and people with disabilities live independently and productively. New research from the Tepper School of Business showed small retailers that the best way to compete with mega-marts is to use their existing customer

data to develop new sales and marketing strategies. Students and faculty in the university's School of Design have collaborated with local foundations to create Explanatoids, cartoons designed to illustrate the importance of science, math and technology to the Pittsburgh region while stressing the role girls play in the careers of the future. Just down the road, faculty in the Heinz College are breaking new ground with studies on the different ways men and women negotiate.

Exploring Research and Creative Projects

Faculty aren't the only people busy with research on campus. Research is a vital component of undergraduate education at Carnegie Mellon. Students can initiate projects of their own or become involved with existing ones on campus. The Department of Biological Sciences, for example, has faculty mentors who help interested students find research opportunities that support their own intellectual curiosity. Drama students participate in every facet of productions, from set construction to acting. Students across campus are encouraged to work with faculty to pursue their own interests, and most departments offer courses for independent study that allow undergraduates to work on projects of their own design under the guidance of a faculty member.

Research projects often come with a financial cost, but Carnegie Mellon offers many sources of funding for students conducting independent research and creative projects. One popular source of funding is the university's Small Undergraduate Research Grant (SURG) program offered through the Undergraduate Research Office. (For more information, see the Undergraduate Research Office section in this catalog under "University Services.") These types of funding programs combined with the support and encouragement offered by faculty and staff on campus bring research - traditionally the mark of graduate education - into the undergraduate realm.

The World of Carnegie Mellon

Carnegie Mellon is often described as a competitive place - and it is. The university selects students from among the best in the world, so attending Carnegie Mellon means that you'll be with students who, like you, were at the top of their classes in high school. The university also stresses collaboration and teamwork, often across disciplines, where students share common goals and tasks while still bringing something unique to the interaction. Carnegie Mellon students are serious scholars who want to excel. The atmosphere is intense and demanding, but also encouraging and rewarding. Carnegie Mellon graduates enter society prepared to assume even greater challenges and equipped with an awareness of their own strengths and abilities.

But Carnegie Mellon students still have fun, and spend their free time engaged in many activities and forging some of the strongest friendships they've ever known. Students don't just develop a solid work ethic at Carnegie Mellon - they develop a strong sense of community. Through residence hall living, community service, group projects and numerous activities and clubs, students find they can belong to a range of communities. Carnegie Mellon also has the tradition of Spring Carnival, an annual three-day event whose buggy races and booths involve students and alumni from a multitude of academic and cultural backgrounds.

Carnegie Mellon Impacts the World

As a Carnegie Mellon graduate, you'll join a highly respected group of individuals who have changed the world as we know it. Whether pursuing further education or entering the work force, alumni consistently achieve the high goals they've set for themselves in a wide variety of academic and professional fields. One alumnus wrote the songs for "Godspell," while an alumna won the Tony Award for Best Performance by a Leading Actress in a Play for her performance in the Pulitzer Prize-winning "Doubt." Carnegie Mellon alumni created and starred in "Hill Street Blues," "L.A. Law," "NYPD Blue," "ER" and "Lost." More than 2,000 of our graduates are corporate chairs, presidents or vice presidents. Some 1,400 alumni are university professors and another 30 are deans. Most major symphonies around the country include Carnegie Mellon alumni. The university's graduates are also prominent in government, and include a former White House staff assistant, a U.N. delegate and a former first deputy chairman of the presidium of the USSR. An astronaut who walked on the moon holds a Carnegie Mellon degree, as does the project director of NASA's Pioneer Interplanetary Probe. Five Carnegie Mellon alumni have gone on to win the Nobel Prize (three in economics, two in physics), and the works of many former art students hang in the permanent collections of more than 50 international museums.

Our Vision

Carnegie Mellon will meet the changing needs of society by building on its traditions of innovation, problem solving, and interdisciplinarity.

Our Mission

To create and disseminate knowledge and art through research and creative inquiry, teaching, and learning, and to transfer our intellectual and artistic product to enhance society in meaningful and sustainable ways.

To serve our students by teaching them problem solving, leadership and teamwork skills, and the value of a commitment to quality, ethical behavior, and respect for others.

To achieve these ends by pursuing the advantages of a diverse and relatively small university community, open to the exchange of ideas, where discovery, creativity, and personal and professional development can flourish.

Our Values

- **Dedication**, as exemplified by our commitment to the critical issues of society and our uncompromizing work ethic.
- **Collaboration**, as exemplified by our interdisciplinarity, our external partnerships, and our capacity to create new fields of inquiry.
- **Measuring excellence by impact**, as exemplified by our focus on issues critical to regional development, national interest, and global welfare.
- **Entrepreneurship**, as exemplified by openness to new ideas, prudent use of resources, and readiness to act.
- **Depth driving breadth**, as exemplified by our issue-driven research, our context-based general education initiatives, and our focus on problem solving and creative production at all levels.
- **Compassion**, as exemplified by our focus on human welfare, on the betterment of society, and on the personal development of the members of our community.
- **Integrity and inclusion**, as exemplified by our attention to the highest ethical standards in all domains, and our commitment to being a community which welcomes talented minds from diverse backgrounds and challenges them individually and collectively to achieve their best.

Carnegie Mellon's undergraduate educational programs are designed to help students acquire the following:

- Depth of knowledge in their chosen areas of specialization and genuine intellectual breadth in other fields.
- Creativity and intellectual playfulness, moving beyond established knowledge and practice to create imaginative ideas and artifacts.
- Skilled thoughtfulness and critical judgment, which allow them to evaluate new ideas, identify and solve or explore problems, and appreciate a variety of different forms of analysis and thought.
- Skills of independent learning, which enable them to grow in wisdom and keep abreast of changing knowledge and problems in their profession and the world.
- A set of values, including commitment to personal excellence and intellectual adventure, concern for the freedoms and dignity of others, and sensitivity to the special professional and social responsibilities that come with advanced learning and positions of leadership.
- The self-confidence and resourcefulness necessary to take action and get things done.
- The ability to communicate with others on topics both within and outside their chosen field of specialization.

Most instruction at Carnegie Mellon is focused on fundamentals useful in later learning, rather than on particulars of knowledge and techniques that may soon become obsolete. Advanced courses provide students with the opportunity to refine their skills by applying and exercising the fundamentals they have acquired in earlier courses and by exploring new analytical and creative directions. In a world that has sometimes placed too little emphasis on skill, Carnegie Mellon takes pride in educating students who display excellence in application - students who can do useful things with their learning.

Values, including sensitivity to the feelings, needs and rights of others, are learned in part through example. To this end, the faculty and staff of Carnegie Mellon work to provide a supportive and caring environment that values and respects intellectual, philosophical, personal and cultural diversity. The faculty strive to identify and discuss with their students, both in formal classroom settings and in a variety of informal contexts, their responsibilities as professionals, citizens and human beings, and to teach through example.

The undergraduate programs at Carnegie Mellon are designed to help our students become accomplished professionals who are broadly educated, independent and humane leaders.

Degrees Offered

The following list shows all primary degrees offered for both undergraduate and graduate students at Carnegie Mellon University.

For a list of minors, please see Undergraduate Options (p. 66).

College of Engineering

Interdepartmental

- M.S. in Engineering and Technology Innovation Management
- M.S. in Energy Science, Technology and Policy

Biomedical Engineering

- B.S. in an engineering discipline and Biomedical Engineering (link) (p. 128)
- M.S. in Biomedical Engineering
- Ph.D. in Biomedical Engineering

Chemical Engineering

- B.S. in Chemical Engineering (link) (p. 134)
- M. Chemical Engineering
- M. Chemical Engineering and Colloids, Polymers and Surfaces
- M.S. in Chemical Engineering
- M.S. in Chemical Engineering and Colloids, Polymers and Surfaces
- M.S. in Colloids, Polymers and Surfaces
- Ph.D. in Chemical Engineering

Civil and Environmental Engineering

- B.S. in Civil Engineering (link) (p. 137)
- M.S. in Advanced Infrastructure Systems
- M.S. in Civil and Environmental Engineering
- M.S. in Civil Engineering
- M.S. in Civil and Environmental Engineering/M. of Business Administration (jointly with the Tepper School of Business)
- M.S. in Computational Mechanics
- M.S. in Environmental Engineering
- M.S. in Environmental Management and Science
- Ph.D. in Advanced Infrastructure Systems
- Ph.D. in Civil and Environmental Engineering
- Ph.D. in Civil and Environmental Engineering/Engineering and Public Policy (dual degree offered with Engineering and Public Policy)
- Ph.D. in Civil Engineering
- Ph.D. in Computational Mechanics
- Ph.D. in Environmental Engineering
- Ph.D. in Environmental Management and Science

Electrical and Computer Engineering

- B.S. in Electrical and Computer Engineering (link) (p. 140)
- B.S. in Music and Technology (jointly with the Department of Music and the School of Computer Science)
- M.S. in Electrical and Computer Engineering
- M.S. in Music and Technology (jointly with the Department of Music and the School of Computer Science)
- Ph.D. in Electrical and Computer Engineering

Engineering and Public Policy

- B.S. in an engineering discipline with an additional major in Engineering and Public Policy (link) (p. 147)
- B.A., B.S., etc. in DC, MCS, or SCS and an additional major in Science, Technology and Public Policy (link) (p. 148)
- M.S. in Engineering and Public Policy
- Ph.D. in Engineering and Public Policy
- Ph.D. in Engineering and Public Policy and an engineering discipline
- Ph.D. in Engineering and Public Policy and Statistics (jointly with the Department of Statistics)

Information Networking Institute

- M.S. in Information Networking
- M.S. in Information Security Technology and Management
- M.S. in Information Technology - Information Security
- M.S. in Information Technology - Mobility
- M.S. in Information Technology - Software Management

Mechanical Engineering

- B.S. in Mechanical Engineering (link) (p. 152)
- M.S. in Computational Design and Manufacturing
- M.S. in Mechanical Engineering
- Ph.D. in Mechanical Engineering

Materials Science and Engineering

- B.S. in Materials Science and Engineering (link) (p. 156)
- M.S. in Materials Science
- M.S. in Materials Science and Engineering
- Ph.D. in Materials Science and Engineering

College of Fine Arts

Architecture

- B. of Architecture (5-year program) (link) (p. 170)
- M.S. in Architecture
- M.S. in Building Performance and Diagnostics
- M.S. in Computational Design
- M.S. in Sustainable Design
- M. of Tangible Interaction Design
- M. of Urban Design
- D. of Professional Practice in Architecture
- Ph.D. in Building Performance and Diagnostics
- Ph.D. in Computational Design

Art

- B.F.A. in Art (link) (p. 175)
- M.F.A. in Art

Design

- B. of Design
- M.A. in Design
- M. of Professional Studies in Design for Interactions
- M. of Design in Design for Interactions
- D. of Design
- Ph.D. in Design

Drama

- B.F.A. in Drama (link) (p. 181)
- M.F.A. in Costume Design
- M.F.A. in Costume Production
- M.F.A. in Directing
- M.F.A. in Dramatic Writing
- M.F.A. in Lighting Design
- M.F.A. in Production Technology and Management
- M.F.A. in Scene Design
- M.F.A. in Sound Design
- M.F.A. in Video and Media Design

Music

- B.F.A. in Music (Composition) (link) (p. 191)
- B.F.A. in Music Performance (link) (p. 191)
- B.S. in Music and Technology (jointly with the Department of Electrical and Computer Engineering and the School of Computer Science) (link) (p. 195)
- M. Music in Composition
- M. Music in Conducting
- M. Music in Music Education
- M. Music in Performance
- M.S. in Music and Technology (jointly with the Department of Electrical and Computer Engineering and the School of Computer Science)

Dietrich College of Humanities and Social Sciences

Interdepartmental

- B.S. in Economics and Mathematical Sciences (jointly offered by the Undergraduate Economics Program and the Department of Mathematical Sciences) (link) (p. 225)
- B.S. in Economics and Statistics (jointly offered by the Department of Statistics and the Undergraduate Economics Program) (link) (p. 209)
- B.A./B.S. in Ethics, History, and Public Policy (jointly offered by the Departments of History and Philosophy) (link) (p. 211)
- B.S. in Information Systems (link) (p. 250)
- B.A. in Linguistics (jointly offered by the Departments of English, Modern Languages, Philosophy, and Psychology) (link) (p. 213)
- B.S. in Neuroscience (jointly offered by the Department of Biological Sciences and the Center for the Neural Basis of Cognition) (link) (p. 83)
- B.S. in Psychology and Biological Sciences (jointly offered by the Department of Psychology and the Department of Biological Sciences) (link) (p. 285)
- B.S. in Statistics and Machine Learning (jointly offered by the Departments of Statistics and Computer Science)

Center for the Neural Basis of Cognition

- Ph.D. in Neural Computation

Economics (jointly offered by Dietrich College and Tepper School of Business unless otherwise noted)

- B.A. in Economics (link) (p. 223)
- B.S. in Economics (link) (p. 224)
- Ph.D. in Economics (Tepper only)
- Ph.D. in Economics and Public Policy (Tepper only, jointly with Heinz College)

English

- B.A. in Creative Writing (link) (p. 232)
- B.A. in English (link) (p. 230)
- B.A. in Professional Writing (link) (p. 233)
- B.S. in Technical Writing and Communication (link) (p. 234)
- M.A. in Literary and Cultural Studies
- M.A. in Professional Writing
- M.A. in Rhetoric
- M. Litt in Investigative Journalism (jointly with the University of Strathclyde [Glasgow, Scotland])
- M. Litt in Renaissance and Early Modern Studies (jointly with the University of Strathclyde [Glasgow, Scotland])
- Ph.D. in Literary and Cultural Studies
- Ph.D. in Rhetoric

History

- B.A./B.S. in Social and Political History (link) (p.)
- B.A. in Global Studies (link) (p. 242)
- M.A. in History
- Ph.D. in History

Modern Languages

- B.A. in Chinese Studies (link) (p.)
- B.A. in French and Francophone Studies (link) (p.)
- B.A. in German Studies (link) (p.)
- B.A. in Hispanic Studies (link) (p.)
- B.A. in Japanese Studies (link) (p.)
- B.A. in Russian Studies (link) (p. 262)
- M.A. in Applied Second Language Acquisition
- M.A. in Second Language Acquisition
- Ph.D. in Second Language Acquisition

Philosophy

- B.A. in Philosophy (link) (p. 273)
- B.S. in Logic and Computation (link) (p. 272)
- M.A. in Philosophy
- M.S. in Logic, Computation and Methodology
- Ph.D. in Logic, Computation and Methodology
- Ph.D. in Philosophy
- Ph.D. in Pure and Applied Logic

Politics and Strategy

- B.S. in International Relations and Politics (link) (p. 277)

Psychology

- B.A./B.S. in Psychology (link) (p. 283)
- B.S. in Cognitive Science (link) (p. 286)
- Ph.D. in Psychology
- Ph.D. in Psychology and Behavioral Decision Research (jointly with the Department of Social and Decision Sciences)

Social and Decision Sciences

- B.S. in Decision Science (link) (p. 289)
- B.S. in Policy and Management (link) (p. 290)
- M.S. in Behavioral Decision Research
- M.S. in Information Technology Strategy (jointly with the Carnegie Institute of Technology and the School of Computer Science)
- M.S. in Social and Decision Sciences
- M.S. in Strategy, Entrepreneurship, and Technological Change (jointly with the Tepper School of Business, Heinz College, and the Department of Engineering and Public Policy)
- Ph.D. in Behavioral Decision Research
- Ph.D. in Psychology and Behavioral Decision Research (jointly with the Department of Psychology)
- Ph.D. in Social and Decision Sciences
- Ph.D. in Strategy, Entrepreneurship, and Technological Change (jointly with the Tepper School of Business, Heinz College, and the Department of Engineering and Public Policy)

Statistics

- B.S. in Statistics (link) (p. 294)
- M. of Statistical Practices
- Ph.D. in Neural Cognition and Statistics (jointly with the Center for the Neural Basis of Cognition)
- Ph.D. in Statistics
- Ph.D. in Statistics and Engineering and Public Policy (jointly with the Department of Engineering and Public Policy)
- Ph.D. in Statistics and Machine Learning (jointly with the Department of Machine Learning)
- Ph.D. in Statistics and Public Policy (jointly with the Heinz College)

H. John Heinz III College

School of Information Systems & Management

Information Security Policy and Management

- M.S. in Information Security Policy and Management

Information Systems Management

- M. of Information Systems Management
- Ph.D. in Information Systems and Management

Information Technology

- M.S. in Information Technology (Business Intelligence and Data Analytics)
- M.S. in Information Technology - Information Security and Assurance
- M.S. in Information Technology - Information Systems Management
- M.S. in Information Technology - Information Technology Management
- M.S. in Information Technology - Software Design and Management
- M.S. in Information Technology - Software Engineering

School of Public Policy & Management

Arts Management

- M. of Arts Management (jointly with the College of Fine Arts)
- M. of Arts Management (jointly with the College of Fine Arts) and Graduate Degree in Innovation and Organization of Culture and the Arts (jointly with the University of Bologna's School of Economics)
- M. of Arts Management (jointly with the College of Fine Arts) and J.D. (jointly with the University of Pittsburgh School of Law)

Biotechnology and Management

- M.S. in Biotechnology and Management (jointly with Mellon College of Science and Tepper School of Business)

Entertainment Industry Management

- M. of Entertainment Industry Management (jointly with the College of Fine Arts)

Health Care Policy and Management

- M.S. in Health Care Policy and Management
- M.S. in Health Care Policy and Management and M.B.A. (jointly with Tepper School of Business)

Medical Management

- M. of Medical Management

Public Management

- M. of Public Management

Public Policy and Management

- M.S. in Public Policy and Management
- M.S. in Public Policy and Management (Policy Analytics)
- M.S. in Public Policy and Management and M.B.A. (jointly with Tepper School of Business)
- M.S. in Public Policy and Management and J.D. (jointly with the University of Pittsburgh School of Law)
- M.S. in Public Policy and Management and M. of Divinity (jointly with the Pittsburgh Theological Seminary)
- Ph.D. in Public Policy and Management
- Ph.D. in Economics and Public Policy (jointly with the Tepper School of Business)
- Ph.D. in Machine Learning and Public Policy (jointly with the School of Computer Science)
- Ph.D. in Statistics and Public Policy (jointly with Dietrich College of Humanities and Social Sciences)
- Ph.D. in Strategy, Entrepreneurship and Technological Change (jointly with Dietrich College of Humanities and Social Sciences, the Carnegie Institute of Technology and the Tepper School of Business)

Adelaide, South Australia Campus

- M.S. in Information Technology
- M.S. in Public Policy and Management

Mellon College of Science

Biological Sciences

- B.A. in Biological Sciences (link) (p. 320)
- B.S. in Biological Sciences (link) (p. 317)
- B.S. in Biological Sciences/Neuroscience Track
- B.S. in Biological Sciences and Psychology (jointly with the Department of Psychology) (link) (p. 319)
- B.S. in Computational Biology (jointly with the Computational Biology Department) (link) (p. 77)
- B.S. in Neuroscience (jointly with the Department of Psychology)
- M.S. in Biological Sciences
- M.S. in Computational Biology (jointly with the Computational Biology Department)
- Ph.D. in Biological Sciences

Chemistry

- B.A. in Chemistry (link) (p. 332)
- B.S. in Chemistry (link) (p. 325)
- B.S. in Chemistry/Biological Chemistry Track
- M.S. in Chemistry
- M.S. in Colloids, Polymers, and Surfaces (jointly with the Department of Chemical Engineering)
- Ph.D. in Chemistry

Mathematical Sciences

- B.S. in Mathematical Sciences (link) (p. 337)
- M.S. in Algorithms, Combinatorics, and Optimization
- M.S. in Mathematical Sciences
- D.A. in Mathematical Sciences
- Ph.D. in Algorithms, Combinatorics, and Optimization
- Ph.D. in Mathematical Finance
- Ph.D. in Mathematical Sciences
- Ph.D. in Pure and Applied Logic (jointly with the Department of Philosophy and the School of Computer Science)

Physics

- B.A. in Physics (link) (p. 349)
- B.S. in Physics (link) (p. 347)
- M.S. in Physics
- Ph.D. in Applied Physics
- Ph.D. in Physics

School of Computer Science

Computer Science

- B.S. in Computer Science (link) (p. 353)
- B.S. in Music and Technology (jointly with the Departments of Electrical and Computer Engineering and Music) (link) (p. 83)
- M.S. in Algorithms, Combinatorics and Optimization
- M.S. in Computational Finance (offered jointly with the Tepper School of Business and the Heinz College)
- M.S. in Computer Science
- M.S. in Computer Science (5th Year Scholars Program only)
- M.S. in Music and Technology (jointly with the Departments of Electrical and Computer Engineering and Music)
- M.S. in Pure and Applied Logic (jointly with the Department of Mathematical Sciences and the Department of Philosophy)
- Ph.D. in Algorithms, Combinatorics and Optimization
- Ph.D. in Computer Science
- Ph.D. in Pure and Applied Logic (jointly with the Department of Mathematical Sciences and the Department of Philosophy)

Human-Computer Interaction

- M.S. in Human-Computer Interaction
- M. of Human-Computer Interaction
- M. of Educational Technology & Applied Learning Sciences (jointly with the Dietrich College of Humanities and Social Sciences)
- Ph.D. in Human-Computer Interaction

Institute for Software Research

- M. of Software Engineering
- M.S. in Information Technology -- eBusiness Technology
- M.S. in Information Technology - Privacy Engineering
- M.S. in Information Technology - Embedded Software Engineering
- M.S. in Information Technology (Software Engineering)
- M.S. in Information Technology - Software Engineering Management
- Ph.D. in Computation, Organizations and Society
- Ph.D. in Software Engineering

Computational Biology Department

- B.S. in Computational Biology (jointly with the Department of Biological Sciences)
- M.S. in Computational Biology (jointly with the Department of Biological Sciences)
- M.S. in Biotechnology Innovation and Computation (jointly with the Language Technologies Institute)
- Ph.D. in Computational Biology

Language Technologies Institute

- M.S. in Language Technologies
- M.S. in Biotechnology Innovation and Computation (jointly with the Computational Biology Department)
- M. of Computational Data Science
- Ph.D. in Language Technologies

Machine Learning

- M.S. in Machine Learning
- Ph.D. in Machine Learning
- Ph.D. in Machine Learning & Public Policy (jointly with the Heinz College)
- Ph.D. in Neural Computation and Machine Learning (jointly with Center for Neural Basis of Cognition)
- Ph.D. in Statistics and Machine Learning (jointly with the Dietrich College of Humanities and Social Sciences)

Robotics Institute

- M.S. in Robotics Technology
- M.S. in Robotics
- M.S. in Robotic Systems Development
- Ph.D. in Robotics

David A. Tepper School of Business

- B.A. in Economics (link) (p. 384)
- B.S. in Economics (link) (p. 385)
- B.S. in Economics and Mathematical Sciences (jointly offered by Dietrich College, the Department of Mathematical Sciences, and Tepper School of Business) (link) (p. 386)
- B.S. in Economics and Statistics (jointly offered by the Tepper School of Business and the Department of Statistics) (link) (p. 387)
- B.S. in Business Administration (link) (p. 374)
- M. of Business Administration (M.B.A.)
- M.B.A./M.S. in Computational Finance (jointly with Dietrich College, Mellon College of Science, and Heinz College).
- M.B.A./M.S. in Public Policy Management (jointly with Heinz College)
- M.B.A./M.S. in Civil and Environmental Engineering (in association with Carnegie Institute of Technology)
- M.B.A. and J.D. in Law (jointly with the University of Pittsburgh Law School)
- M.B.A./M.S. in Health Care Policy Management (jointly with Heinz College)

- M.B.A./M.S. in Software Engineering (jointly with the School of Computer Science)
- M.S. in Computational Finance (jointly with Dietrich College, the Mellon College of Science, and Heinz College)
- Ph.D. in Accounting
- Ph.D. in Algorithms, Combinatorics, and Optimization (jointly with the School of Computer Science and Department of Mathematical Sciences)
- Ph.D. in Economics
- Ph.D. in Finance
- Ph.D. in Information Systems
- Ph.D. in Management of Manufacturing and Automation (with Robotics Institute)
- Ph.D. in Marketing
- Ph.D. in Operations Management and Manufacturing
- Ph.D. in Operations Research
- Ph.D. in Organizational Behavior and Theory
- Ph.D. in Economics and Public Policy (jointly with Heinz College)
- Ph.D. in Strategy, Entrepreneurship, and Technological Change (jointly with the Department of Social and Decision Sciences, Heinz College, and the Department of Engineering and Public Policy)

University-Wide, Intercollege, and Joint Degree Programs**Architecture-Engineering-Construction Management Program**

- M.S. in Architecture-Engineering-Construction Management (jointly with the Department of Civil and Environmental Engineering and the School of Architecture)
- Ph.D. in Architecture-Engineering-Construction Management (jointly with the Department of Civil and Environmental Engineering and the School of Architecture)

BXA Intercollege Degree Programs

- B. of Humanities and Arts (jointly with the Dietrich College of Humanities and Social Sciences and the College of Fine Arts) (link) (p. 88)
- B. of Science and Arts (jointly with the Mellon College of Science and the College of Fine Arts) (link) (p. 105)
- B. of Computer Science and Arts (jointly with the School of Computer Science and the College of Fine Arts) (link) (p. 109)

Communication Planning and Information Design Program

- M. Design in Communication Planning and Information Design (jointly with the School of Design and the Department of English)

Computational Finance Program

- B.S. in Computational Finance (jointly with the College of Humanities and Social Sciences, Heinz College, Mellon College of Science and Tepper School of Business) (link) (p. 77)
- M.S. in Computational Finance (jointly with the College of Humanities and Social Sciences, Heinz College, Mellon College of Science and Tepper School of Business)

Entertainment Technology Center

- M. of Entertainment Technology

Integrated Innovation Institute

- M. of Integrated Innovation for Products and Services

Science and Humanities Scholars Program

- B.A./B.S. in various disciplines (jointly with the Dietrich College of Humanities and Social Sciences and the Mellon College of Science) (link) (p. 86)

Carnegie Mellon University in Qatar

Qatar Biological Sciences

- B.S. in Biological Sciences
- B.S. in Computational Biology

Qatar Business Administration

- B.S. in Business Administration

Qatar Computer Science

- B.S. in Computer Science

Qatar Information Systems

- B.S. in Information Systems

Undergraduate Admission

Michael A. Steidel, Director of Admission
Office: Warner Hall, Admission Lobby, First Floor
<http://www.cmu.edu/admission>

Admission Philosophy

At Carnegie Mellon, we select our freshman class from a large group of very qualified candidates. We don't use a calculation to arrive at our admitted class. Calculations can't take into account all of the factors we like to consider when making admission decisions. We treat every application individually and take great care in making our admission practices fair, thorough and sensitive. We are interested in students who can be successful at Carnegie Mellon and take full advantage of all the university has to offer and enriching our campus community.

Admission Criteria

The majority of our applicants are admissible and could be successful at Carnegie Mellon. We use a variety of factors to select our first-year class from those admissible candidates. High school performance weighs most heavily in our admission decision because it is the most meaningful measure of a student's abilities. We pay close attention to the type of courses taken and to the grades received, and to the challenges you've given yourself in the classroom. If you are applying to programs in the arts, your artistic performance will be either the main factor or a significant factor (depending on the program) in our admission decision.

Standardized test scores add to our knowledge of a student's ability, but we cannot make decisions simply on the basis of test scores alone. The high school record and standardized test scores (SAT Reasoning Test or Act with Writing and SAT Subject Tests) work together to make up the academic portion of a student's evaluation.

Carnegie Mellon is an exciting campus because of the positive qualities and experiences our students bring with them. For this reason, we're interested in the kinds of things students do beyond the classroom, whether they participate in extracurricular activities, work part-time or pursue hobbies. Knowing what students like to do on their own time gives us a feeling for each student's personality, motivation and sense of responsibility. All of this is an important part of the admission process.

Expressing an interest in learning more about Carnegie Mellon can only enhance a student's application. We strongly recommend that students come to the Carnegie Mellon campus to interview with a member of our staff, although it's not required. This adds a personal touch to our evaluation and gives students a chance to ask questions. If you cannot make it to campus, consider talking with a local Carnegie Mellon alumni representative. There are a number of other ways to show interest and learn more about Carnegie Mellon. Students can come to one of our Turn Tartan Weekends, attend an information program in or near their town, interview in their hometown with one of our staff members or alumni, or enroll in one of our summer programs. Information about a number of these events is included at the end of this section.

Different Criteria for Different Colleges

Each college at Carnegie Mellon has special admission criteria specifically related to each course of study.

Admission to the Schools of Drama and Music is based primarily on an audition or portfolio review. Applicants to the Schools of Architecture, Art and Design will be evaluated not only on the basis of their portfolio but also on their academic performance.

Candidates for the College of Engineering, the Mellon College of Science, and the School of Computer Science will be evaluated on the basis of academic performance, and we will look additionally for strength in mathematics and science. Academic performance is also the main criteria we use to evaluate applicants to the Dietrich College of Humanities and Social Sciences, the Information Systems program and to the Tepper School of Business' undergraduate program. In these cases, we emphasize reading and comprehension abilities as well as mathematics courses.

No one single grade, factor or score will automatically grant or deny a student admission to Carnegie Mellon. Students should be aware of all the admission requirements-secondary school preparation, standardized test requirements, nonacademic information, counselor, teacher and interview recommendations-when submitting applications. We will use the sum total of these different factors when making our admission decisions. Because we want to have a sense of who the student is as a person, we look closely at the essay and personal statement the student is asked to write, the guidance counselor's evaluation and the teacher's recommendation.

Freshman Application Instructions

- Applicants must apply online by completing the Common Application and submitting the \$75 application fee. We require this fee of all applicants except in extenuating family financial circumstances. A College Entrance Examination Board Application Fee Waiver, an ACT Application Fee Waiver, or a letter from a secondary school counselor or principal requesting an application for a waiver must be submitted.
- Request that your secondary school counselor submit all high school transcripts, including senior year courses and mid-year grades, and a school profile to the Office of Admission, preferably online, as close to January 1 as possible.
- Apply for admission only to the specific college(s) or programs in which you're interested.
 - Rank your program and/or major preference.
 - You may apply to up to three colleges/programs.
 - If you're applying to more than one college/program, there's no need to submit multiple applications and there's no additional application fee.
 - Be sure to meet the admission requirements for each college/program.
 - Early Decision and transfer candidates will only be considered for their first choice college/program.
- If you're applying to the College of Engineering, Dietrich College of Humanities and Social Sciences, Information Systems, Mellon College of Science, School of Computer Science and Tepper School of Business, We strongly urge you to indicate a program and/or major preference at the time you apply. Although you might not declare a major until the end of your freshman or sophomore year, we do limit access to certain majors, such as electrical and computer engineering, computer science and business.
- If you're applying to the College of Fine Arts (CFA), you must apply specifically to one of the following schools: Architecture, Art, Design, Drama or Music. (See specific instructions to follow.)
- If you are applying to the School of Music, the additional audition fee is \$50 and if you are applying to the School of Drama the additional audition fee is \$85 and only payable online by VISA or MasterCard, at the time of reserving your audition online at <http://www.cmu.edu/admission/finearts>
- Take the SAT Reasoning Test or ACT with Writing and SAT Subject Tests preferably by November, but no later than December. If you are applying to art, design, drama or music, SAT Subject Tests are not required.
 - Scores must be official scores from the Educational Testing Service (ETS). Copies should not be sent. When registering for the tests, request that an official Score Report be sent directly to Carnegie Mellon. This request can also be made later by getting an Additional Report Request Form from your guidance office. The Carnegie Mellon code is 2074.
 - Register for your tests at least six weeks prior to the test date.
- The Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS) should be taken if your native language is not English. Carnegie Mellon requires 102 or better on the IBT TOEFL, and an IELTS scores of 7.5 or above. Please arrange to have these scores sent no later than January 1.
- If you are applying to the College of Fine Arts' Schools of Architecture, Art, Design, Drama, or Music, you must complete portfolio review or audition requirements. Please go to <http://www.cmu.edu/admission/finearts> for further information. The Schools of Art, Architecture, Design, Drama and Music require that students apply to the university before registering for an audition or portfolio review. There is no Early Decision consideration given for the acting, directing, music theater, music and technology, or the BXA programs.
- You must sign the "Confidentiality Statement" on the Common Application School Report Form and give it to your secondary school counselor for completion. Your counselor should return this form, along with the school profile and your transcript.
- Choose a teacher to complete the Common Application Teacher Recommendation Form and make sure it is submitted to the Office of Admission by the application deadline.
- Our Regular Decision application deadline is January 1. The Schools of Drama and Music's Regular Decision deadline is December 1.
- If you are applying for financial aid, complete a Free Application for Federal Student Aid (FAFSA) at <http://www.fafsa.gov>. Carnegie Mellon's Title IV code is 003242. You must also complete the CSS PROFILE at <https://>

profileonline.collegeboard.com and submit signed copies of parent and student tax documents. See www.cmu.edu/admission for more details.

Application Notification

- Students applying under the Early Decision Plan will be notified of our decision by December 15.
- Students applying under the Regular Decision Plan will be notified of our decisions by April 15.
- Students who are applying for financial aid will also receive financial aid decisions by April 15 provided they submitted their financial aid forms by the preferred financial aid deadline of February 15.

If you are offered admission and wish to enroll at Carnegie Mellon, you are required to pay an \$800 non-refundable enrollment deposit by May 1 (Candidates General Reply Date), even if you are receiving financial aid, in order to reserve places in the freshman class and in university housing. This deposit will be credited to your first semester's charges. The admission staff assumes that a student's deposit to Carnegie Mellon is his or her only deposit. We reserve the right to cancel our offer of admission if a student posts a tuition deposit at another university. During the summer, information concerning registration, enrollment, insurance, orientation, housing and dining services, etc., will be sent to all students.

Deferred Admission

If you are admitted to Carnegie Mellon and wish to defer your admission for one year, you must submit a request in writing to the Office of Admission. If permission is granted, your enrollment deposit must be paid in order to confirm enrollment for the following year. You cannot enroll in a degree program at another institution in the interim.

Application Plans

Early Decision Plan

If Carnegie Mellon is your first choice, you may want to consider applying Early Decision. Under this plan, applicants are notified of our admission decision early in the senior year. If you are accepted Early Decision, we expect you to enroll in Carnegie Mellon. Under the Early Decision plan, we encourage you to submit applications to other schools. However, if you are accepted to Carnegie Mellon, we require you to withdraw your applications from other schools.

Early Decision is available to all programs, with the exception of acting, music theater, directing, music and technology or the BXA programs.

Early Decision Applications are due November 1 and students will be notified of an admission decision by December 15. If you are admitted under Early Decision, you are required to withdraw all admission applications to other colleges or universities and post a non-refundable enrollment deposit of \$800 within two weeks of your admission notification.

Regular Decision Plan

Regular Decision is our most popular application option. The deadline is January 1 (December 1 for drama and music applicants). You will be notified of our decision by April 15. Admitted students will have until May 1 (Candidate's General Reply Date) to accept our offer of admission.

Early Admission

Through the process of Early Admission, the university admits certain highly qualified applicants at the end of their junior year in high school. In general, Early Admission candidates are highly mature and responsible students who have usually exhausted the courses offered at their high schools without receiving a high school diploma. We expect students who apply for early admission to follow the same procedures as regular freshman applicants. We also strongly encourage applicants to have a personal interview with a member of the Office of Admission staff. It is important to note that the College of Fine Arts very rarely accepts Early Admission applicants.

Transfer Applicants

Transfer students are admitted to Carnegie Mellon under policies that vary from college to college. If there is space in the requested program, we will base our decision on your college grades, college recommendations, high school grades and test scores (SAT Reasoning Test or ACT with Writing and SAT Subject Tests, if available). In the College of Fine Arts, most transfer applicants compete with freshman applicants for a place in the entering class.

Transfer Application Instructions

1. Apply for admission to the specific college of interest, noting departmental preference. If interested in music or drama, student should specify the option. Transfer students will be considered only to their first-choice college. Please do not apply to more than one college.

Engineering, DC, IS, MCS, SCS or Tepper:

- Fall transfer possible if space is available
- Spring transfer extremely limited and unlikely
- No external transfers accepted into BHA/BSA/BCSA

CFA:

- Fall transfer possible
- No spring transfer opportunities (except for advanced students in the School of Music)
- If you are interested in the School of Music or Drama, specify the option
- No external transfers accepted into BHA/BSA/BCSA

2. Enclose a non-refundable fee of \$75 (and audition fees if applicable). This application fee is required, except in extenuating family financial circumstances.
3. Send all transcripts that reflect secondary school and college/university studies to the Office of Admission. We also require a copy of course descriptions from a college catalog from each college/university you attended. Course descriptions should be sent by email to <mailto:undergraduate-admission@andrew.cmu.edu> with the subject line "Transfer Course Descriptions." Course descriptions should be copied and pasted into a single .doc or .pdf document, and must have your name and address on the first page.

IMPORTANT: If you have applied to Carnegie Mellon within the past three years, you must resubmit an updated application with fee (and audition fee if appropriate) and all other materials required of transfer students. You do not have to submit high school records.
4. If you are applying to the Schools of Architecture, Art, Design, Drama or Music, you must complete any portfolio or audition requirements. You must complete and submit the application for admission by December 1.
5. Sign the "Confidentiality Statement" on the Secondary School Report. Give this form and your completed application for admission to a dean or an advisor at the college you attended (or are currently attending). Your dean or advisor should complete and return the form and application directly to the Office of Admission.

IMPORTANT: Carnegie Mellon prefers that all forms and documents be submitted at the same time. If they must be sent separately, make sure to print your full name and social security number at the top of each document.
6. Transfer application deadlines are as follows:
 - Spring transfer: October 15
 - Fall transfer: March 1 (December 1 for CFA applicants)
7. If you are applying for financial aid, complete a Free Application for Federal Student Aid (FAFSA) at <http://www.fafsa.gov>. Carnegie Mellon's Title IV code is 003242. You must also complete the CSS Profile at <https://profileonline.collegeboard.com> and submit signed copies of parent and student tax documents. See <http://www.cmu.edu/admission> for more details.

If planning on:	File FAFSA by this date:
Spring transfer	November 1
Fall transfer (CFA)	February 15
Fall transfer (all other colleges)	May 1

IMPORTANT: If you are applying for financial aid as a transfer student, you must send a Financial Aid transcript of aid applied for and/or received at all colleges previously attended. Even if you didn't receive any aid, federal regulations require that the college(s) attended complete the form.

Admission and financial aid award notification dates for transfer students:

Spring transfer:	December 15 or soon after
Fall transfer(CFA):	April 15
Fall transfer (all other colleges):	During month of June

Make arrangements to have a final copy of your college transcript(s) sent to Carnegie Mellon.

Deposit Information for Transfers

If you are offered admission for the spring semester, Carnegie Mellon does not require a tuition deposit (due to the short time interval between December 15 and the start of the second semester). If you are offered admission to the College of Fine Arts for the fall semester, you must pay a non-refundable deposit of \$800 by May 1, even if you are receiving financial aid. If you are offered admission to Engineering, DC, IS, MCS, SCS, or Tepper for the Fall semester, you must pay a non-refundable \$800 deposit by June 15, even if you are receiving financial aid. The enrollment deposit will reserve your place at the university and a place in university housing if available. It will be credited to the first semester charges.

IMPORTANT: If you accept our offer of admission, Carnegie Mellon assumes that the tuition deposit to Carnegie Mellon is your only tuition deposit. We reserve the right to cancel our offer of admission if you post a tuition deposit at more than one university. Enrollment deposits received after the deadline may be returned if space is no longer available.

University Housing for Transfers

Carnegie Mellon expects to accommodate most transfer students who request university housing, however, it is not guaranteed. The Off-campus Housing Advisory and Referral Service is available to help you locate housing accommodations in the local area.

Transfer Credit Evaluated on Individual Basis

Carnegie Mellon's departmental faculty will determine transfer credit for courses you've taken at other universities. Transfer credit is considered on an individual basis. We may award elective credit for courses with no Carnegie Mellon equivalent. In some instances, the College Council may recommend a special program of study for you to meet the university's graduation requirements.

Transfer credit for courses you are taking while we review your existing college record depends upon successful completion of each course. Grades are not transferred - only credit is. You may receive transfer credit for elective courses you've taken but will still have to take Carnegie Mellon courses to fulfill the elective space in your chosen degree program. Sometimes transfer students have to take specific courses and accumulate a larger total number of credits than the normal amount required for graduation. The time it takes for you to graduate will depend on the time you need to complete the full university degree requirements - not on class standing at a previous institution.

If you transfer into CIT, IS, MCS, SCS or Tepper in the Fall semester, you will receive an estimate of the additional academic work that you must complete in order to fulfill the university degree requirements. If you transfer into CIT, IS, MCS or SCS in the Spring semester, you will have the opportunity to meet with a dean or department head in order to outline the additional academic work that you must complete in order to meet the university degree requirements. If you transfer into DC in the fall or spring semester, you'll receive a credit and requirement review of the work you've completed at your previous institution(s). It is best for transfer students in CFA to assume freshman status. Occasionally advanced standing is awarded based on review of previous college courses.

Application as an International Student

International students should apply to Carnegie Mellon using the same procedures outlined for either freshmen or transfer students. Also note this additional information:

- Carnegie Mellon does not offer financial aid or installment plans to international students. International students are not eligible for application fee waivers.
- If your native language is not English, you are required to take the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). Carnegie Mellon requires 102 or better on the IBT TOEFL or an IELTS score of 7.5 and above. Please arrange to have these scores sent no later than January 1.

Advanced Placement Consideration

Advanced Placement Program

Carnegie Mellon recognizes the Advanced Placement program and may grant advanced placement and credit for test scores of four or five. We encourage eligible students to take the AP examinations. We will receive the test scores in early summer for those students who have requested that their results be sent to Carnegie Mellon. The appropriate academic deans will evaluate your scores, and in late summer, you will be informed of the AP credit awarded.

College Level Course Work

The university may also award placement and credit for college work completed during high school. Applicants who have taken college courses should arrange to have their college transcripts along with course catalogs or descriptions sent to the Carnegie Mellon Office of Admission for transfer credit evaluation and advanced placement.

International Baccalaureate Program

Carnegie Mellon also recognizes the International Baccalaureate Examination and may grant advanced standing and/or credit in various fields if scores on the higher level examination range from six and seven. The results of the IB exams should be sent to Carnegie Mellon, where the appropriate dean will evaluate the scores. In late summer, you will be notified of the credit that has been awarded.

BXA Intercollege Degree Programs

Bachelor of Computer Science and Arts (BCSA)

The Bachelor of Computer Science and Arts (BCSA) Program is an intercollege degree-granting program. It is designed for students who would like to combine their interests in the fine arts and computer science rather than pursue a conventional major and degree in either the College of Fine Arts or the School of Computer Science. To be considered for the BCSA program, you must apply and be admitted to both CFA and SCS (you must check the CFA box and SCS box on the Common Application). This program is only open to directing and production technology and management for Drama and composition, music performance and music technology for Music. Not all students admitted to both colleges are selected for the BCSA program.

Bachelor of Humanities and Arts (BHA)

The Bachelor of Humanities and Arts (BHA) program is an intercollege degree-granting program. It is designed for students who would like to combine and blend their interests in fine arts and humanities/social sciences rather than pursue a conventional major and degree in either the College of Fine Arts (CFA) or the Dietrich College of Humanities and Social Sciences (DC). To be considered for the BHA program, a student must apply and be admitted to both CFA and DC (you must check the CFA box and DC box on the Common Application). This program is not open to music theatre or acting majors. Not all students admitted to both colleges are selected for the BHA program.

Bachelor of Science and Arts (BSA)

The Bachelor of Science and Arts (BSA) program is an intercollege degree-granting program. It is designed for students who would like to combine studies in both the fine arts and natural sciences/mathematics rather than pursue a conventional major and degree in either the College of Fine Arts (CFA) or the Mellon College of Science (MCS). To be considered for the BSA program, a student must apply and be admitted to both CFA and MCS (you must check both the CFA box and MCS box on the Common Application). This program is not open to music theatre or acting majors. Not all students admitted to both colleges are selected for the BSA program.

With the BXA programs, you must include with your application a statement of intent (essay) describing your interdisciplinary goals in both academic areas and how the BXA program would provide the opportunity and framework for you to accomplish these objectives. This essay is a central component in the selection process. The BXA statement of intent fulfills the essay requirement on the supplement. You do not need to complete another essay. If you are selected for this program, you will be notified in your admission decision letter. These programs are not available under Early Decision.

College of Fine Arts Requirements

Deadlines

- Early Decision applicants must submit a complete admission application, including any required artistic evaluation, by November 1 (Drama applicants must meet this deadline if they choose the November audition date).
- Regular Decision applicants must submit a complete admission application by January 1 (or December 1 if applying to drama or music) and all audition or portfolio review reservations should be made before this date.

Communication of Information and Admissions Decisions

- Once you have registered for the appropriate audition or portfolio review at admission.enrollment.cmu.edu/pages/college-of-fine-arts, you will receive further instructions from us via email.
- Final admission decisions are not made at the time of your audition or portfolio review. We will consider the artistic evaluation as part of your application along with your other credentials and notify you by April 15 (December 15 for Early Decision applicants).

Please visit admission.enrollment.cmu.edu/pages/college-of-fine-arts for details regarding the specific requirements for fine arts auditions and portfolio reviews.

Exploring Carnegie Mellon

Visiting a campus is one of the best ways for you to discover which school is right for you. We strongly recommend that you attend an information session or interview with a member of the admission staff while on campus. Admission interviews allow us the opportunity to get to know our applicants. Interviews are considered in the admission process and help the admission committee make better, more informed decisions with determining the freshman class. During the interview, you'll have the opportunity to ask questions about admission requirements, financial aid, student life, Pittsburgh - and much more!

On-campus auditions and portfolio reviews usually include an interview with a member of the Fine Arts faculty and a campus tour. Therefore, only one campus visit is necessary for fine arts students.

Campus Tours

Campus tours are conducted by Andrew Ambassadors and leave from the Office of Admission, 101 Warner Hall. On most weekdays during the academic year, we conduct four tours daily. Please visit the website (<http://admission.enrollment.cmu.edu/pages/tour-campus>) for exact dates and times campus tours are offered.

Hometown Interviews

Although we strongly recommend a campus visit, we realize that it is not always possible for you to come to campus. The Admission staff does travel to various parts of the country interviewing students in their hometowns. Information about making an appointment will be mailed to students prior to the time we arrive in your city. Students who interview on campus do not have to schedule another interview in their hometown. The specific dates and locations for Hometown Interviews are listed online at <http://admission.enrollment.cmu.edu/pages/interviews-with-the-office-of-admission>

Alumni Interviews

We encourage students to talk with a member of the Carnegie Mellon Admission Council (CMAC). CMAC, a select group of alumni, helps the Admission staff reach out to prospective students. Alumni interviews are as valuable when making admission decisions as interviews with the Admission staff. If you're interested in interviewing with a member of CMAC, please visit <http://admission.enrollment.cmu.edu/pages/interview-with-alumni>. (<http://admission.enrollment.cmu.edu/pages/interview-with-alumni>)

Turn Tartan Overnight Weekends

The more information you have, the better decisions about college you'll make! The Admission staff invites you to learn more about Carnegie Mellon by living like a university student for a day and a half in our Turn Tartan Overnight (<http://admission.enrollment.cmu.edu/pages/turn-tartan-overnight>) program. Visits begin on Sunday morning and last through Monday afternoon.

Information Sessions

The Office of Admission offers two different information sessions throughout the year, both on and off campus. Carnegie Mellon Preview Sessions, offered in the Spring, are meant for freshmen, sophomores and juniors in high school, who are looking for a general overview of the college search process. Carnegie Mellon's Information Sessions for High School Seniors, available in the Summer and early Fall, offer an in-depth look at the university. During the informational program, you'll have the opportunity to learn more about Carnegie Mellon's areas of study, the admission process and admission requirements, how to apply for financial aid and our campus and alumni through exciting video testimonials. Check out the schedule and register at <http://admission.enrollment.cmu.edu/pages/information-sessions>.

Call Carnegie Mellon for Assistance

If a student will need assistance while visiting the campus, due to a physical or learning disability, he/she should call us at 412-268-2082, and we will help meet the student's needs during his/her visit at Carnegie Mellon.

Directions to Campus

Directions to Carnegie Mellon's campus from the north, east, south, west and the airport are available at <http://admission.enrollment.cmu.edu/pages/maps-directions>. Please call (412) 268-8343 to listen to a recorded message of these directions to campus by phone. If you are using a GPS, the following address will take you to the East Campus Parking Garage: **5040 Forbes Avenue, Pittsburgh, PA 15213**.

Summer Opportunities

The campus is in full operation during the summer, populated by students and faculty from a variety of programs. The university continues to have outstanding, innovative educational programs extending beyond regular involvement with its degree candidates. Six such programs are offered during the summer for high school students: the Pre-College Programs in the Fine Arts (Architecture, Art & Design, Drama and Music), the Advanced Placement Early Action Program and the Summer Academy for Mathematics and Science. Three sessions of summer school are held for college students who wish to make up or advance their degree program studies. Every service and support organization is available to summer students: the Computer Center, the Health Center, the Counseling Center, the libraries, the Office of Admission, the Career Center, Student Activities, etc.

Summer Pre-College Programs for High School Students

Office of Admission, Warner Hall 2nd Floor

The Pre-College Programs are designed to preview an actual college experience. Our programs afford high school students many opportunities for personal growth and development within a university setting. A wide range of social, cultural, and recreational activities are planned by a staff of resident counselors to fully integrate the students' lives on campus and in Pittsburgh. Movies, dances, museum and gallery visits, field excursions or attendance at professional theater productions, concerts, and Pittsburgh Pirates games are just a few of the sponsored activities.

Summer Academy for Mathematics and Science

Students with diverse backgrounds who are entering their junior or senior year and considering careers in engineering, science and other math-based disciplines are eligible to participate in this rigorous program. Traditional classroom instruction, along with creative "hands-on" projects will allow students to apply concepts and principles.

Advanced Placement Early Admission Program

Overview

The main purpose of the Advanced Placement Early Admission (AP/EA) Program is to provide the opportunity to take university courses at Carnegie Mellon for talented, motivated high school students. Students earn college credit while working in an academic environment mirroring that which the student would encounter during the first year of college.

Students who complete two courses in the AP/EA Program and who can graduate early from high school have the unique opportunity to apply Early Admission. By attending the AP/EA program during the summer of 2013, students who will be high school juniors in the fall of 2013 will have a strong understanding of college life and academics. These rising juniors are eligible to apply Early Admission by January 1, 2014, and if accepted can start as full-time degree students here in the fall of 2014. Students admitted under Early Admission are not obligated to accept the offer of admission until May 1.

All AP/EA students may also apply to Carnegie Mellon during their senior year, through Early Decision (various deadlines in November and December depending on the college) or Regular Decision (January 1 deadline, or December 1 for the College of Fine Arts).

Regardless of whether students choose to apply to Carnegie Mellon, successful AP/EA students can leverage their experiences here as demonstration of their ability to succeed in college. AP/EA courses are college courses, not AP classes, and as such they count toward graduation requirements here and are widely accepted elsewhere. Students applying to another college or university can request an official Carnegie Mellon transcript be sent to that institution. Any use of AP/EA courses to satisfy high school requirements should be approved ahead of time by an appropriate high school official.

While most of the participants in the program will have just completed their junior or senior year of high school, suitably qualified students at early grade levels can participate. However, in order to stay in university housing, students must be at least 16 years old. This does not apply to commuters.

AP/EA Coursework

Our APEA courses are regular Carnegie Mellon classes, so you should anticipate intense, college-level work. Many of the APEA faculty members are the same faculty who teach during the regular school year. Upon admission to the program, students will select their courses from the Schedule of Classes. View the 2015 AP/EA Course List (<http://goo.gl/BYcePS>) for more information.

As an APEA student, you'll be required to take two courses during the summer. This two-course schedule completed in six weeks is comparable in demand to the typical five-course schedule completed in a semester.

The flexible APEA program allows you to take:

- Two math/science/engineering courses
- One math/science/engineering course and one humanities/social sciences course
- Two humanities/social sciences courses

Some features of the APEA classes include:

- meet daily
- small class size
- personal learning environment
- supplemental tutoring
- taught by faculty selected for their enthusiasm and experience teaching college-level material to younger students

Pre-requisites

High school preparation is necessary for some AP/EA classes. For more details, consult the course descriptions or contact the program director.

Calculus requires:

Algebra, trigonometry and geometry. Pre-calculus or an equivalent course is recommended.

Computer science requires:

Knowledge of computers or some computer experience in high school is helpful but not required. PSAT Math of 65 or higher, or SAT Math of 650.

Physics, chemistry and biology require:

Students enrolled in physics, chemistry, biology or engineering must have completed a physics, chemistry or biology high school course.

Students with special qualifications may apply for permission to enroll in a third course with an additional non-refundable charge. Carrying three courses in the AP/EA program is not generally recommended.

Pre-College Architecture Program

Overview

The study of architecture is an exciting multidisciplinary activity that combines design creativity, historical perspective, technical excellence, social responsibility, and global and environmental leadership. The Pre-College Architecture Program is structured to introduce you to each of these areas and for you to experience studying architecture in a university setting.

Primary Goals of Pre-College Architecture

Pre-College will provide you with a strong foundation and give you a clear idea of what to expect at a college level architectural program. The mix of seminars, workshops, drawing and digital media classes will introduce you to some of the theory, process and methodology of current design practice. The experience of working in the studio environment is quite different from the traditional classroom that you may be used to, giving you the opportunity to begin to develop your own design sensibility as you work iteratively through the creative process.

The Value of Attending Pre-College

Pre-college is a good opportunity to test the fit of architecture with your career goals and expand upon your creative and technical skills, providing a solid head start if you decide to enter this field of study. Project work is partnered with a focus on documentation and techniques to communicate your ideas visually. We run workshops to assist you in photographing your work and creating a strong portfolio, which is an essential part of a student's presentation package.

Coursework

The studio curriculum is designed to allow you to move freely between physical and virtual spatial investigations. Work alternates between theoretical projects represented through image and model, and installation projects created at full-scale. Installations are produced collaboratively and will immerse you in hands-on making, approaching the work in terms of material behavior, tectonic systems, and perceptual experience. These full-scale projects allow you to learn from physical engagement with the spaces you have designed; this experience and spirit of experimentation will inform and strengthen your individually created theoretical work.

No prior design, drawing or computer experience is necessary; if your skills in these areas are more advanced, our faculty and program will challenge you to develop them further. The ratio in the design studio is 1:12. At the conclusion of the summer program, you will have a private consultation with your design professor and receive a written letter of evaluation regarding your progress and aptitude in all courses. You will also receive 9 units of elective credit at Carnegie Mellon should you later enroll in the School of Architecture as an undergraduate student.

Pre-College Art and Design Program

Overview

The Pre-College Art and Design program motivates, stimulates and prepares you as emerging artists and designers. Exploring traditional tools and new technologies in a variety of media leads you to develop conceptual and technical skills as well as your portfolio – all excellent preparation for applying to and succeeding in college-level art and design programs. Challenging courses, stimulating workshops, museum and gallery field trips, and energetic interaction with dedicated faculty and talented peers introduce you to the spirit and substance of an art and design school culture and environment.

Coursework

During the Pre-College Program, you will attend morning and afternoon classes, Monday through Friday. You'll work in our beautiful, spacious studios in the historic College of Fine Arts building and Margaret Morrison Carnegie Hall.

The Pre-College faculty at Carnegie Mellon are accomplished artists, designers and educators who share their expertise inside and outside the classroom. With small class sizes, you'll benefit from their individual attention, intense instruction and substantial constructive feedback. Instructors provide written evaluations of your work upon completion of the program.

Your instructor to student ratio will be about 1:13, promoting opportunities for questions and discussion. Although the pre-college program has its own particular aspects, the underlying philosophy is similar to the first year of our regular undergraduate art and design curricula. At the end of the program, each student meets with a faculty member to discuss his/her performance in the program, and to address questions regarding documentation and presentation of work and portfolio preparation. The program concludes on a celebratory note, inviting parents and friends to see the unique work produced over the course of the three-week or six-week session.

Studio Environment

Students work together in a large studio with individual workspaces. Sessions include individual instruction, in-class work sessions, critiques, lectures and field trips.

There is an array of events and opportunities to enhance and supplement studio work, including:

- Weekly figure drawing
- Visits to local galleries such as the Carnegie Museum of Art
- Visits to Pittsburgh based design firms
- Evening presentations by faculty on their own art and design work
- Exhibitions of Carnegie Mellon student work
- Portfolio preparation and critique sessions

Pre-College Drama Program

Overview

The Pre-College Drama Program gives students the chance to participate in a professional training program with three options: acting, music theatre and design/technical production. The program focuses on the exploration of a conservatory training program with emphasis on creativity, craft and discipline.

Coursework

The Pre-College Drama curriculum focuses on process rather than results. Nevertheless, the culmination of the program is an audition or portfolio review. These events are mandatory for all students whether or not they plan to apply to Carnegie Mellon for admission.

The audition/portfolio reviews take place during the last two days of the program. Acting and music theatre students will perform two contrasting, two-minute monologues. In addition, music theatre students will participate in dance and vocal auditions. Design/Production students will experience portfolio reviews and interviews with faculty.

Every student will receive an evaluation of his or her coursework along with advice for future development in the profession.

Pre-College Music Program

Overview

Instruction is challenging, creativity is expected and the responsibility of making music and training musicians is taken very seriously. At Carnegie Mellon, we are proud of our history in which tradition and technology co-exist. The School of Music has graduated superb musicians who are known worldwide as performers, composers, conductors and educators.

The Program

The Pre-College Music Program offers a unique view of the life of a music student at Carnegie Mellon in a supportive environment of study and performance. It is an ideal opportunity to experience a world-class conservatory program and discover your potential for a career in music. Coupled with the rich cultural life of the city of Pittsburgh and varied campus activities, the Pre-College Music Program is an extraordinary way for young musicians to spend their summer.

The Pre-College Music Program will give you the opportunity to see what college is like. This is not high school and it is not camp. You get to live on campus, take classes with conservatory professors, play, rehearse, perform and enjoy the freedom of college life in a safe environment.

National High School Game Academy

Overview

The National High School Game Academy (NHSGA) explores the video game industry and the skills needed to be successful in it. The program includes an exciting blend of hands-on exercises combined with traditional lecture and discussion. Students are encouraged to expand their own creative possibilities in a unique blend of left- and right-brain college-level work.

Inspired by the Carnegie Mellon graduate program, Entertainment Technology, the NHSGA is structured to give students a taste of the current state of video game development and provide guidance toward embarking on their own career in the video game industry.

Video games are now a major force in the world of popular entertainment. Video game sales, in the U.S., have outgrown the film industries annual box office sales. Plus, this industry is still growing with the emergence of casual gaming, online gaming and serious gaming, so companies are continually looking for passionate, creative and talented individuals.

The program encourages all students to apply. No particular technical or artistic skills are needed. Regardless of your background, if you are interested in exploring the world of video game development, the National High School Game Academy is the program for you.

While creating a real college-level environment, students are encouraged to explore their interests, expand their technical knowledge and develop their interpersonal skills. They will learn about job opportunities in the industry and what is needed to be competitive in this job market. There is a misconception that if one is good at playing video games then they will be good at creating video games. Students in this program will discover just how much hard work and talent is needed to be successful.

Coursework

The six-week program consists of daily lectures on various topics concerning video game development and the industry itself, followed by four-hour studio sessions in the afternoon where various specific skills classes and workshops are held. All of these courses will be hosted at the Entertainment Technology Center which is located just off main campus. Students will be bussed the short distance to and from the main campus every day.

Upon applying for the National High School Game Academy, students will need to declare an Art Focus or a Programming Focus. While all students will take classes in all three areas of art, programming and game design, their declared focus will dictate the length of time they spend in each area. On the first day of class, each of these two focus areas will then be split into three additional groups (Beginner, Intermediate and Advanced) in order to aid us in providing a challenging level of study for all students. If a student is a beginner, or unsure of which focus to take, or is an accomplished programmer already then it is suggested that they choose the Art Focus so that they can explore a new area of study at the NHSGA.

While the emphasis of the National High School Game Academy is to acquaint the student with the process of video game development, that effort is focused through the building of playable game demos and game assets. Students will develop a portfolio of their completed work and will present them for play testing and critique. Parents are again encouraged to attend this final afternoon session and see firsthand what has been accomplished.

At the end of the program, every student will receive an evaluation of his or her coursework along with advice for future development in college studies that would help him or her best prepare for this profession.

Further Information

Requests for applications and further information should be addressed to:

Pre-College Programs
Office of Admission
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213-3890
(412) 268-2082
FAX: (412) 268-7838

Division of Enrollment Services

Lisa Krieg, Director of Enrollment Services / Director of Risk Initiatives / Associate Vice President for Campus Affairs

Office: Warner Hall A19
http://www.cmu.edu/hub

The Division of Enrollment Services includes six administrative departments: The HUB, University Registrar's Office, Student Financial Aid, Student Accounts Office, Summer Studies, and Campus Affairs Systems. The division leads and delivers integrated administrative services that support students' academic goals from enrollment through graduation. At the same time, the staff strives to champion collaborative administrative services and counsel for all CMU campuses and programs in alignment with the university's strengths in technology and effectiveness.

2015-2016 Cost of Attendance

The budgets depicted below reference a typical Resident, Commuter or Off-Campus Student. The university reserves the right to change its charges without notice.

The academic year tuition charges are for all full-time undergraduate students. A full-time student is one registered in a degree program and carrying a schedule of at least 36 units per semester. A student enrolled for less than 36 units per semester will be charged tuition on a per-unit basis.

Note: All incoming freshmen are required to live on campus. Permission to live off-campus must be granted by Student Affairs.

Freshmen Entering Fall 2015

Per-unit tuition rate: \$690

	Resident	Commuter
Tuition	49,610	49,610
Orientation Fee (Fall semester only)	255	255
Activity Fee	250	250
Transportation Fee	150	150
Media Fee	10	10
Technology Fee	390	390
Room & Fees (2)	7,520	0
Dining (1)	5,310	2,570
Books/Supplies & Miscellaneous (3)	2,400	2,400
Transportation Allowance (3, 4)	0	680
Totals	\$65,895	\$56,315

Undergraduate Students Who Entered Fall 2014 & Fall 2013

Per-unit tuition rate: \$690

	Resident	Commuter	Off-Campus
Tuition	49,610	49,610	49,610
Activity Fee	250	250	250
Transportation Fee	150	150	150
Media Fee	10	10	10
Technology Fee	390	390	390
Room & Fees (2)	7,520	0	7,020
Dining (1)	5,310	2,570	5,000
Books/Supplies & Miscellaneous (3)	2,400	2,400	2,400
Transportation Allowance (3, 4)	0	680	0
Totals	\$65,640	\$56,060	\$64,830

Undergraduate Students Who Entered Fall 2012

Per-unit tuition rate: \$683

	Resident	Commuter	Off-Campus
Tuition	49,120	49,120	49,120
Activity Fee	250	250	250
Transportation Fee	150	150	150
Media Fee	10	10	10
Technology Fee	390	390	390
Room & Fees (2)	7,520	0	7,020
Dining (1)	5,310	2,570	5,000
Books/Supplies & Miscellaneous (3)	2,400	2,400	2,400
Transportation Allowance (3, 4)	0	680	0
Totals	\$65,150	\$55,570	\$64,340

Undergraduate Students Who Entered Fall 2011

Per-unit tuition rate: \$676

	Resident	Commuter	Off-Campus
Tuition	48,660	48,660	48,660
Activity Fee	250	250	250
Transportation Fee	150	150	150
Media Fee	10	10	10
Technology Fee	390	390	390
Room & Fees (2)	7,520	0	7,020
Dining (1)	5,310	2,570	5,000
Books/Supplies & Miscellaneous (3)	2,400	2,400	2,400
Transportation Allowance (3, 4)	0	680	0
Totals	\$64,690	\$55,110	\$63,880

Undergraduate Students Who Entered Fall 2010 and Earlier

Per-unit tuition rate: \$670

	Resident	Commuter	Off-Campus
Tuition	48,180	48,180	48,180
Activity Fee	250	250	250
Transportation Fee	150	150	150
Media Fee	10	10	10
Technology Fee	390	390	390
Room & Fees (2)	7,520	0	7,020
Dining (1)	5,310	2,570	5,000
Books/Supplies & Miscellaneous (3)	2,400	2,400	2,400
Transportation Allowance (3, 4)	0	680	0
Totals	\$64,210	\$54,630	\$63,400

Footnotes:

- The commuter dining amount is based upon 14 meals per two weeks.
- Off-campus room rate is estimated at resident room minus \$500 and off-campus board is resident board minus \$310. Non-freshmen resident board is freshmen resident board minus \$310.
- These expenses will not appear on your Student Account Invoice. *Design/Architecture/Art Students: No additional add-on for books.*
- Transportation for resident and off-campus students varies based on home state.

Health Insurance

In addition, minimal health insurance coverage is required at an estimated cost of \$1,144/year, unless a waiver is granted because you are covered under your family's health plan. Enhanced health insurance coverage is suggested for international students at an estimated cost of \$2,500/year. Complete information about the university's Health Insurance Policy and options, as well as the waiver requirements, is available at <http://www.cmu.edu/health-services/student-insurance/>.

The HUB

Brian Fernandes, Associate Director of Enrollment Services
Office: Warner Hall A12, 5000 Forbes Avenue, Pittsburgh, PA 15213-3890
Phone: (412) 268-8186
Fax: (412) 268-8084
E-mail: thehub@andrew.cmu.edu

The HUB staff delivers comprehensive service and counsel to students and families regarding financial aid, billing and payment, registration, academic records, and ID Card services. In direct support of student enrollment and persistence, The HUB offers students and families highly integrated information through personal attention and technologically responsive tools in a professional, forward-thinking, and accessible environment.

The Assistant Directors in The HUB serve as contacts for specific colleges and assist enrolled students with key aspects of the enrollment process – financial aid, billing and registration. Contact information for assigned HUB Assistant Directors can be found on The HUB website (<http://www.cmu.edu/hub/hours.html>). Assistant Directors can be contacted for specialized enrollment questions.

For general questions and information, please e-mail thehub@andrew.cmu.edu or call (412) 268-8186 during regular office hours: Monday, Wednesday, and Friday between 8:30 a.m. and 4:30 p.m. or Tuesday and Thursday between 10:30 a.m. and 4:30 p.m.

ID Card Services

Office: The HUB, Warner Hall, 5000 Forbes Avenue Pittsburgh, PA 15213-3890
 Phone: (412) 268-5224
 Fax: (412) 268-8084
 E-mail: idplus@andrew.cmu.edu

One of the most important items you will need at Carnegie Mellon is your official identification card. Your ID Card identifies you as a member of the Carnegie Mellon community. Your ID Card will be part of your everyday life on campus and is used to access the following:

- University Housing Residence Halls
- Computing Services & Computer Clusters/Labs
- University Libraries
- Local Port Authority Transit (bus, incline, etc.)
- Dining Services Meal Plans
- Computer Store
- University Center Retail Shops
- Athletic Facilities

For a full list of services that can be accessed using the ID Card, visit www.cmu.edu/idplus/services.

Plaid Cash

One beneficial feature of your ID Card is Plaid Cash. Plaid Cash is a prepaid, stored-value/debit account that is accessible via your ID Card. It is a convenient, cashless way to pay on and off campus. You can use Plaid Cash for textbooks, school supplies and laundry tokens. Many of the area's most popular businesses accept Plaid Cash; it can be used to pay for restaurant meals, take-out, delivery and more. View a list of participating businesses at www.cmu.edu/idplus/plaidcash/locations.html.

Student Advantage

A four-year Student Advantage membership can be added to your ID Card. With Student Advantage, you can receive discounts of up to 50% off at more than 20,000 locations nationwide. Learn how to add Student Advantage at www.cmu.edu/idplus/sa.

University Registrar's Office

John Papinchak , University Registrar
 Fax: (412) 268-6651
 E-mail: university-registrars-office@andrew.cmu.edu

The University Registrar's Office (URO) performs the essential roles of administering the collection and maintenance of student records, ensuring their accuracy and integrity, and enforcing academic policies while providing the best possible services. The University Registrar's Office aspires to provide exceptional, environmentally-conscious services, while anticipating and meeting growing customer requirements with innovative processes, training and self service applications. The office strives to foster and promote an environment of professional development and appreciation.

The University Registrar's Office produces a complete calendar of important dates and deadlines for the academic year, which can be found on The HUB website (<http://www.cmu.edu>).

Undergraduate Enrollment

Enrollment is the process whereby eligible students notify Enrollment Services that they will be attending the university by registering for courses and settling their student accounts. Enrollment must be completed before students may begin classes and before they may utilize university facilities.

Complete information about the enrollment process, as well as registration and payment deadlines, are listed on the Official Academic Calendar, located on The HUB website (<http://www.cmu.edu>).

Registration

Registration is the process of selecting courses for the upcoming semester and discussing those selections with an academic advisor. We strongly encourage you to meet with your academic advisor before you finalize your selections and register for courses using Student Information Online (SIO) (<https://s3.as.cmu.edu/sio/#schedule-registration>).

For most entering freshmen, registration is accomplished during the summer, with the assistance of Associate Deans and department heads.

Academic placement and elective choice information is collected by mail questionnaires during June and July. Most freshmen receive their schedules and enrollment information prior to the first day of classes.

Currently enrolled students select their courses for the upcoming semester during Registration Week, prior to the end of each semester. The Schedule of Classes is available online prior to Registration Week, listing available courses along with general enrollment information. The university reserves the right to make changes to hours, units or instructional staff when such changes seem necessary or advisable. A link to the online Schedule of Classes is provided on The HUB website (<http://www.cmu.edu>). Although faculty advisors are provided, it is the responsibility of students to have clearly in mind what they intend to do, what elective courses they wish to pursue and what irregularities exist which may affect their present schedule.

Students are not permitted to register in courses for which the prerequisites have not been satisfied. Exceptions to the rule may be granted only upon the recommendation of the teaching department concerned. Unless the prerequisites are satisfied or special approval is obtained when the student enters the course, no credit can be allowed for the course.

PCHE Cross-Registration

Cross-College and University Registration Guidelines - PCHE (Pittsburgh Council on Higher Education)

Cross-registration provides opportunities for enriched educational programs by permitting full-time paying undergraduate and graduate students to cross register for one course at a Pittsburgh Council on Higher Education (PCHE) Institution. Students who are paying full-time Carnegie Mellon tuition (per the requirements of their home college) are eligible. The PCHE course may not count towards full-time status. There is no additional tuition charge, except for special course or laboratory fees. Carnegie Mellon students do not acquire status at the Host Institution, but are given library and bookstore privileges. Credit and grades are transferred directly to the home institution. Cross-registration is not applicable during the Summer Session(s) or during intersessions.

For more information, visit <http://www.cmu.edu/hub/registration/undergraduates/cross/>

Faculty Course Evaluations (FCEs)

Students play an integral role in the academic life of the university when they participate in the evaluation of the faculty through the Faculty Course Evaluation process. FCE data is important in the evaluation of teaching and learning, as an important piece of the promotion and tenure process and as part of the process of course design and improvement. Student participation in the FCE process is critical to the university's commitment to quality teaching and academic excellence. Students are strongly encouraged to participate in the process with constructive feedback that is relevant to teaching and course content. More information on the University Course Assessment process and results from previous years can be found at the FCE website (<http://www.cmu.edu/hub/fce>).

Student Financial Aid

Linda Anderson , Director of Student Financial Aid
<http://www.cmu.edu/finaid/>

In alignment with the university's enrollment goals, Student Financial Aid consistently optimizes the utilization of all financial aid resources in order to recruit and retain a high quality and diverse student population. Student Financial Aid strives to deliver superior services that exceed the expectations of students, parents, and internal and external constituencies. Student Financial Aid identifies, creates and delivers strategies that facilitate the integration of financial aid policies. These policies align with current and future university recruitment, retention and enrollment priorities.

How Aid Works

Our financial aid program is need-based, meaning that all aid eligibility is determined by a student's family's financial circumstances. While a student and his/her family have the primary responsibility for paying for college, financial aid can bridge the gap between the total costs and the family's ability to pay.

We use a standard method to carefully review a family's financial circumstances and establish an expected contribution from the student and family. If we determine that the family cannot meet the student budget

based on that calculated amount, we will award or recommend scholarships, grants or other resources.

For more information, visit <http://www.cmu.edu/finaid/basics/undergraduate/how.html>.

Applying for Financial Aid

Complete steps for applying for financial aid can be found at <http://www.cmu.edu/finaid/basics/undergraduate/applying.html>.

Types of Financial Assistance Available

There are several types of financial aid available to students, such as the following:

- Federal and Private Loans
- University Scholarships
- Outside Scholarships
- Federal and State Grants
- Student Employment

A full listing of these, as well as more information on each type, is available at <http://www.cmu.edu/finaid/basics/undergraduate/types.html>.

Carnegie Scholarship

Carnegie Mellon offers a Carnegie Scholarship to incoming freshmen. Carnegie Scholarships are awarded to academically and artistically talented middle income students who qualify for little to no need-based financial aid. Carnegie Scholarships are open to all qualified U.S. citizens and permanent residents, regardless of race or national origin. Students must apply for need-based financial aid to be considered.

Students must submit the 2014-2015 FAFSA in order to be considered for Carnegie Scholarships. Besides the FAFSA, if awarded a Carnegie Scholarship, students must complete the CSS PROFILE and submit all required tax documents before the scholarship will be credited toward the student's account. Scholarship winners will be notified in their notification of financial aid.

The Carnegie Scholarship is renewable for 8 semesters of undergraduate education (ten semesters for Architecture students), if satisfactory academic performance is maintained and you are assessed Carnegie Mellon tuition. The scholarship is only awarded to incoming freshmen during the admission process and renewed annually if the student meets the cumulative 2.0 QPA requirement.

Students with a parent who is an Carnegie Mellon employee who qualifies for tuition remission are not eligible for a Carnegie Scholarship.

Satisfactory Academic Progress

The Department of Education requires recipients of Federal Title IV Financial Assistance to meet academic progress standards each year. Federal Title IV Financial Assistance includes the Federal Pell Grant, Federal Supplemental Educational Opportunity Grant, Federal Perkins Loan, Federal Work-Study, Federal Direct Student Loan and Federal Direct PLUS Loan Programs. Each university determines its own policy regarding sufficient progress standards. Federal academic progress standards must include two elements: cumulative QPA and cumulative units. At Carnegie Mellon, we define this as follows: first-year freshman students must pass 80 percent of all cumulative units attempted at Carnegie Mellon and have a 1.75 cumulative QPA after the first year, all other students (excluding graduate students in the Tepper School of Business and Heinz) must pass 80 percent of all cumulative units attempted at Carnegie Mellon and have a 2.00 cumulative QPA.

Carnegie Mellon has established a maximum time-frame of twelve (12) semesters for students to finish a program and receive financial aid.

Outside Scholarships

If you receive outside scholarships, they will be used to meet your unmet financial need and where applicable, offset/reduce loans and workstudy.

Institutional grants and scholarships will not be reduced due to the receipt of outside scholarships unless one of the following conditions occur:

1. If you receive federal grants or loans, these funds, in combination with any outside scholarships, cannot exceed your financial need.
2. All outside scholarships, in combination with all aid received, cannot exceed your cost of attendance.

Outside scholarships are not from federal, state or institutional (school) sources, such as a Federal Pell Grant or FSEOG. Examples of outside scholarships are: Coca Cola, Rotary scholarships, etc.

Students Pursuing a Second Bachelor's Degree

If you are enrolling in a second bachelor's degree program, you are not eligible for grants/scholarships. However, you may be eligible to receive funds from student loan and student employment programs. Eligibility for student loan funds is contingent upon the student's prior loan indebtedness.

Study Abroad

There are three ways to pay for study abroad at Carnegie Mellon: exchange programs (departmental or university-wide), sponsored study abroad, and external programs. For more detailed information, visit the Office of International Education website (<http://www.studentaffairs.cmu.edu/oie>).

Undergraduate Tuition Exchange Programs

Carnegie Mellon University assesses the standard tuition charge for the undergraduate tuition exchange programs.

Since Carnegie Mellon assesses the tuition charge, the student can be considered for all forms of institutional, state, and federal aid for which the student may have eligibility with the exception of any student employment program.

Undergraduate Study Abroad Programs

Carnegie Mellon University does not assess the tuition charge for undergraduate Study Abroad Programs.

Since Carnegie Mellon does not assess the tuition charge, the student is not considered for any institutional grants and scholarships. However, Carnegie Mellon will consider any student participating in an approved Study Abroad Program for all state and federal student aid programs for which the student may have eligibility with the exception of any student employment program.

The U.S. Department of Education and Carnegie Mellon University define an approved Study Abroad Program as one which is part of a contractual agreement between Carnegie Mellon and the host institution. Additionally, courses taken in the Study Abroad Program must be accepted for transfer to Carnegie Mellon by the Dean of the student's college.

Undergraduate Sponsored Study Abroad Programs

Carnegie Mellon assesses full tuition charges and all applicable fees to students participating in an undergraduate sponsored study abroad program.

Undergraduate International Students

Documentation Eligibility (U.S. Citizenship or Eligible Noncitizen)

You must be a U.S. Citizen or Eligible Noncitizen to receive federal student aid. If you are a U.S. Citizen, but were not born in the United States, please send us documentation of your citizenship (e.g., a copy of your passport or naturalization certificate). If you are an Eligible Noncitizen or refugee, send us verification. Acceptable forms of verification include a photocopy of both sides of your I-551 or I-551C card.

Undergraduate international students are ineligible to receive any federal or state student financial aid. Additionally, Carnegie Mellon does not award any institutional financial aid funds to undergraduate international students.

Student Accounts Office

Brian Hill, Director of Student Accounts
E-mail: student-accounts@andrew.cmu.edu

The Student Accounts Office serves the university's various academic and administrative departments by processing and invoicing all student-related financial activity and managing the corresponding student financial obligations resulting from this activity. The office strives to serve students by accurately reflecting and communicating these financial obligations, providing timely and consistent responses to inquiries, and instilling financial responsibility and accountability with clear and concise guidance.

Billing Information

University Charges

All charges incurred at the university are reflected on your student account. Charges include tuition and fees and may include housing, dining, sorority or fraternity charges, health insurance, Plaid Cash, DineXtra and any miscellaneous charges incurred. Miscellaneous charges may include, but are not limited to, music lessons, library fines, parking fines, or emergency loans.

Student Account Invoices (E-Bills)

Student account invoices (E-Bills) are produced on the last day of each month. Invoices detail all transactions processed in the month, as well as any charges due in the future. Students receive an e-mail notification from the Student Accounts Office when a new E-Bill is ready for viewing on Student Information Online. Payments for amounts due from a monthly E-Bill must be received by the 15th of the next calendar month.

All student account invoices are available to view, print, or download through Student Information Online (SIO). Students can log onto Student Information Online (<https://s3.as.cmu.edu/sio/#home>) with their Andrew ID and password.

Billing Authorizations

Since paper student account invoices are not produced and mailed, students can authorize Carnegie Mellon to send a copy of their E-Bill to another individual (parent, spouse, etc.) or other individual bill payer's e-mail address. After completing the authorization process, designated recipients will receive an e-mail with a PDF attachment of the E-Bill and any related billing messages.

More information can be found at <http://www.cmu.edu/hub/ebill-mps-instructions>

Student Account Interest Charges

Any amounts not paid by the stated due date are subject to a 1.5% interest charge each month until the balance is paid in full.

Tuition Assessment

The tuition charged to each student will be automatically adjusted on the 10th regularly scheduled class day (refer to the specific date noted in the Official University Calendar (<http://www.cmu.edu/hub/calendar.html>) as the "last day to add courses") based upon each student's schedule at that time. The tuition charged will be increased whenever the number of units added justifies tuition charges greater than those paid by the student at the time of fee settlement. After that time, no tuition adjustments will be made, with the exception of second minis for that particular semester.

For additional information, see University Policies (p. 45).

Payment Options

Carnegie Mellon University is pleased to offer a wide variety of payment options to students and their families. A full listing of these, as well as more information on each type, is available at <http://www.cmu.edu/hub/billing/payment/index.html>.

Refunding

Refunds

If a student account has a negative balance resulting from an overpayment, financial aid, or a reduction of charges, the Student Accounts Office will review the account and issue a refund. If you have a negative balance and do not want a refund to be generated, please contact The HUB so they can update your account.

Electronic Refunds

The Student Accounts Office encourages all students to authorize electronic deposit of their student account refunds directly into their U.S. checking or savings accounts. Taking advantage of this opportunity eliminates the need to stand in line at The HUB to pick up a refund check and makes the funds available to the student within two business days. To enroll, students simply need to add a bank account on Student Information Online (<https://s3.as.cmu.edu/sio>).

Paper Checks

If you have not signed up to receive electronic refunds, your refund will be generated as a paper check that must be picked up in The HUB. Students who are issued a paper check for a student account refund have six months to cash the check. If the check is not cashed within six months, it will be voided and credited back to the student account and applied to any outstanding charges.

University Policies

<http://www.cmu.edu/policies>

Policy on Cheating and Plagiarism

Students at Carnegie Mellon are engaged in preparation for professional activity of the highest standards. Each profession constrains its members with both ethical responsibilities and disciplinary limits. To assure the validity of the learning experience a university establishes clear standards for student work.

In any presentation, creative, artistic, or research, it is the ethical responsibility of each student to identify the conceptual sources of the work submitted. Failure to do so is dishonest and is the basis for a charge of cheating or plagiarism, which is subject to disciplinary action.

Cheating includes but is not necessarily limited to:

1. Plagiarism, explained below.
2. Submission of work that is not the student's own for papers, assignments or exams.
3. Submission or use of falsified data.
4. Theft of or unauthorized access to an exam.
5. Use of an alternate, stand-in or proxy during an examination.
6. Use of unauthorized material including textbooks, notes or computer programs in the preparation of an assignment or during an examination.
7. Supplying or communicating in any way unauthorized information to another student for the preparation of an assignment or during an examination.
8. Collaboration in the preparation of an assignment. Unless specifically permitted or required by the instructor, collaboration will usually be viewed by the university as cheating. Each student, therefore, is responsible for understanding the policies of the department offering any course as they refer to the amount of help and collaboration permitted in preparation of assignments.
9. Submission of the same work for credit in two courses without obtaining the permission of the instructors beforehand.

Plagiarism includes, but is not limited to, failure to indicate the source with quotation marks or footnotes where appropriate if any of the following are reproduced in the work submitted by a student:

1. A phrase, written or musical.
2. A graphic element.
3. A proof.
4. Specific language.
5. An idea derived from the work, published or unpublished, of another person.

Computing and Information Resources Code of Ethics

The ethical principles which apply to everyday community life also apply to computing. Every member of Carnegie Mellon has two basic rights: privacy and a fair share of resources. It is unethical for any other person to violate these rights.

Privacy

- On shared computer systems every user is assigned an ID. Nobody else should use an ID without explicit permission from the owner.
- All files belong to somebody. They should be assumed to be private and confidential unless the owner has explicitly made them available to others.
- Messages sent to other users should always identify the sender.
- Network traffic should be considered private.
- Obscenities should not be sent by computer.
- Records relating to the use of computing and information resources are confidential.

Resources

- Nobody should deliberately attempt to degrade or disrupt system performance or to interfere with the work of others.

- Loopholes in computer systems or knowledge of a special password should not be used to alter computer systems, obtain extra resources, or take resources from another person.
- Computing equipment owned by departments or individuals should be used only with the owner's permission.
- University resources are provided for university purposes. Any use of computing for commercial purposes or personal financial gain must be authorized in advance. Many of the agreements that the university has specifically forbid this activity.
- Computing and information resources are community resources. Theft, mutilation, and abuse of these resources violate the nature and spirit of community and intellectual inquiry.

System Administration

- On rare occasions, computing staff may access others' files, but only when strictly necessary for the maintenance of a system.
- If a loophole is found in the security of any computer system, it should be reported to the system administrator and not used for personal gain or to disrupt the work of others.
- The distribution of programs and databases is controlled by the laws of copyright, licensing agreements, and trade secret laws. These must be observed.

This code of ethics lays down general guidelines for the use of computing and information resources. Failure to observe the code may lead to disciplinary action. Offenses that involve academic dishonesty will be considered particularly serious.

Policies on Examinations

Preamble

The Faculty Senate adopted the following policies on the administration of examinations for the undergraduate courses (defined as courses that are numbered 6xx or below). These policies represent an understanding between faculty and student concerning an important but often stressful period, especially at the conclusion of each academic semester and at mid-semester. There should be no expectation that the following points will cover every conceivable situation. The student should anticipate the demands of the exam schedule, plan accordingly and early, and be prepared. The faculty should recognize that the student is encumbered with many tightly orchestrated and intensive obligations during this period over which he or she has no control: expectations should be reasonably consistent with the number of course units and, of course, should be made known to the student well in advance of the final examination period, preferably as part of the course syllabus.

In order to help students plan their time and study optimally for examinations, this document lays out in some detail the policies regarding final and in-term examinations. Instructors are requested to provide notification of the major in-term examinations in the course syllabus. The final examination date is posted early in the semester. It is the responsibility of the student to give his or her instructor sufficient notice and to work with the instructor to reschedule examinations if this is needed.

Definitions

- Final examination period. The university's official final examination period begins on the Monday immediately following the last day of classes and continues through the last day of scheduled final examinations, with the exception of reading day(s).
- Scheduled final examinations. Scheduled final examinations are those scheduled by Enrollment Services.
- Self-scheduled examinations. An instructor may choose not to fix a schedule for the final examination, but instead allow each student to choose the examination time; such exams are called self-scheduled examinations.
- Final examinations. Final examinations can either be comprehensive, covering all course materials, or non-comprehensive, covering only a part of the course.
- In-term examinations. Major examinations during the semester are referred to here as in-term examinations.

I. In-Term Examinations

1. All in-term examinations should be given during the regularly scheduled class time. However, if the exam requires additional time to complete,

then examinations may be administered outside of regularly scheduled class time.

2. No examinations given outside of class time (excluding make ups and self-scheduled examinations) shall be administered on a Friday after 4:30 pm, or at any time Saturday or Sunday.
3. The instructor administering an exam (or another required class event) that falls outside class time must make any and all reasonable accommodations to provide an alternative time to students who have conflicts with the proposed time period, including those conflicts due to activities, meetings, other classes, etc. (provided that the instructor is notified of such conflict in a timely manner).
4. No student shall be required to take more than two full-period in-class or out-of-class examinations on the same day. It is the responsibility of the student to notify the instructor in a timely manner of his/her circumstance so that appropriate accommodations can be made.

II. Final Examinations

1. All scheduled final examinations are held at the end of the semester during the university's official final examination period. Comprehensive final examinations are not required for each course, but are given at the option of the department or instructor. The reading day and weekend preceding the examination days shall never be used for examination purposes of any kind, unless a student opts to take a self-scheduled examination during this time. Non-comprehensive final examinations or final projects (but not both) are allowed during this final examination period only in courses that do not give a final comprehensive examination.
2. Instructors are expected to return all work assigned no later than the last regular day of classes in courses for which there is a final examination. In cases when this is not possible, an answer key, solution sets or equivalent feedback should be provided unless the final examination will not cover material in work that has not been returned.
3. No other coursework, including laboratory or studio work, will be due during the final examination period unless it is assigned in advance and in lieu of the course's final examination. Regardless of whether there is a final examination in the course, no classes other than review sessions shall be held during the final examination period. Review sessions should be scheduled for optimal attendance, and a serious effort should be made to accommodate students who cannot attend. In appreciation of the time required to prepare for final examinations, no other examinations, portfolio reviews, critiques or juries shall be scheduled for the last class day of a course with a final examination.
4. Instructors shall never exert or submit to pressures to move an examination so that people can leave earlier nor pressure students to take an examination on a reading day or weekend preceding examinations.
5. No student is required to take more than two scheduled examinations that start within a 25-hour period. A student who has more than two examinations scheduled within a 25-hour period or has two examinations scheduled at the same time should first contact the instructors of the courses for assistance in resolving conflicts. If the problem cannot be resolved by that means, the student should contact the associate dean of his or her home college.
6. Take-home final examinations shall be given for any 24-hour period of the student's choosing during the final examination period.
7. Students are expected to present themselves at the place assigned at the start of the examination; late arrival will reduce the total time a student has to complete the examination, unless instructor's course policy indicates otherwise. Instructors reserve the right to require attendance within a specific time period. Students who miss an examination with a reasonable excuse and wish to petition for a make-up final examination should check with the instructor. Instructors are encouraged to include late arrival policy and make-up exam policy in the course syllabus.
8. Any student shall be permitted to review his or her corrected, graded final examination in the presence of an instructor or a teaching assistant. Any controversy arising from this review shall be dealt with in accordance with the university procedure for the appeal of grades and academic actions. A final examination that is not returned to a student will be kept available for a year for review. In the event that the instructor or teaching assistant is not available for the review, the responsibility shall rest with the department head of the instructor offering the course or his or her designee. Since instructors are expected to return all work assigned before the final examinations, they are not responsible for retaining unclaimed coursework.
9. Concerns related to final examination, complaints about violations of the final examination policy or alterations of the final examination schedule should be directed to the department head of the instructor offering the course or to the associate dean of the student's home college.

Contact

Questions concerning this policy or its content should be directed to the Vice Provost for Education, (412) 268-5865.

Final Examination Conflict Guidelines

Recognizing that students will, on occasion, encounter foreseeable or unforeseeable conflicts with scheduled final examinations, the following guidelines have been approved by the University Education Council (UEC), the Associate Deans' Council (ADC), and the Associate Deans for Graduate Programs (ADGP) to inform the actions of students and the decisions of instructors.

Foreseeable Conflicts:

Before negotiating any exam conflicts, students should recognize the following expectations. Students should carefully consider the dates of each semester's final exam period as reflected in the university's official academic calendar. Until the university publishes the detailed final examination schedule (usually by early October in the Fall semester and by late February in the Spring semester), students should plan according to the assumption that their final exams could be scheduled for any day/time during the final exam period. Therefore, students should avoid making any personal arrangements (such as travel) that could ultimately conflict with the final exam period.

In developing the final examination schedule, the University Registrar's Office deploys significant effort in consultation with associate deans to minimize direct and 25-hour conflicts for individual students. Once the final exam schedule is published for the semester, each student should immediately review the schedule to determine whether there are conflicts. If the student's schedule presents any final exams that directly conflict with each other, or if the student's schedule presents more than two final exams to begin in a twenty-five hour period, then the student is responsible for immediately initiating the following process so that the relevant instructors can reach a timely and effective resolution that is consistent with university policy (noting that no action is necessary if a student voluntarily elects to take the exams according to the published schedule):

1. The student should begin by discussing the conflict with all relevant instructors to determine if they can suggest a resolution. This discussion should be completed at least two weeks prior to the exams.
2. If one of the course instructors offers an alternate time for the exam, the student must agree to that resolution unless another exam conflicts with the alternate proposed time.
3. If a resolution cannot be found, the following hierarchy is recommended for compromise (Student's Home Department > Student's College > Smallest Course Size > Higher Course Level):
 - If one of the courses is offered in the student's home department, the home department should be the first to accommodate.
 - If the course is offered within the student's home college, then the student's college should accommodate a course that is not within the student's college.
 - An instructor teaching a smaller course size should accommodate before an instructor from a larger course size accommodates.
 - Finally, if a resolution still has not been reached, an instructor teaching a higher course level should accommodate before an instructor from a lower course level accommodates.

At any point during this process, the student's academic advisor or academic associate dean from the home academic college may be consulted to verify the existence of the conflict and assist in the negotiation and resolution.

Other foreseeable conflicts may be personal in nature, such as a religious holy day or observance, or a singular, significant obligation. As stated earlier, students are expected to review the final exam schedule as soon as it is published to identify such conflicts. A student faced with such a conflict should first exhaust all reasonable means to otherwise resolve it. If such efforts are unsuccessful, then the student should immediately contact the instructor and explain the circumstances, recognizing that the current Policy on Examinations (<http://www.cmu.edu/policies/documents/Exams.htm>) does not require the instructor to offer an alternate exam time in response to foreseeable, personal conflicts. The mutual respect and goodwill between instructor and student should guide their negotiation of such conflicts as they attempt to balance the student's needs with those of the academic enterprise. At any point in the process, the student's academic advisor, academic associate dean and/or student affairs liaison may be consulted to assist in identifying reasonable accommodations or solutions.

Students hoping to resolve cases involving foreseeable conflicts should expect that their instructors may require them to take a rescheduled final examination on the Make Up Final Exam Day (<http://www.cmu.edu/hub/courses/exams/makeup-faq.html>).

Unforeseeable Conflicts

In exceptional circumstances, a student may encounter a medical, personal or family emergency that unexpectedly interferes with his/her ability to participate in a scheduled final examination. When encountering such a situation, the student should contact the instructor as soon as is reasonably possible, and ideally before the final examination has been administered.

The student's academic advisor, academic associate dean and/or student affairs liaison may serve as both advocate for the student and point of verification for the instructor. After reviewing the matter, should an accommodation be granted by the instructor, the instructor may elect to institute one of several options, including: rescheduling the exam for later in the final examination period; assigning an "I" incomplete grade until a make-up exam can be administered in the following semester; or utilizing another method for resolving missed exams that has been outlined in the course syllabus.

Student Health Insurance Policy

Reason for Policy

The high cost of health care in the United States presents a potentially serious health and financial risk to students and their accompanying dependents. The absence of adequate insurance coverage can result in temporary or permanent interruption of a student's education. The university is committed to offering student health insurance that provides access to quality health care and achieves a balance between premium cost and adequate coverage without overburdening students' financial resources. This balance is best achieved through a mandatory/hard waiver insurance program that mitigates the effect of adverse selection.

Policy Statement General Requirements

All full-time students are required to carry health insurance and will be assessed a charge for the individual basic mandatory plan offered through the university student health insurance program. The charge will appear on the invoice of the first semester of attendance in the academic cycle. The student is required to take one of the following three actions:

1. Enroll in the basic plan as charged.
2. Upgrade the benefit plan by enrolling in the enhanced student health insurance options during the open enrollment period.
3. Apply for a waiver from the mandatory plan.

Requirements for Waiver

Application for a waiver from the university student health insurance plan must be made to Student Health Services by the last day of the open enrollment period. Students applying for waiver must provide documentation of continuing coverage verifying that they are enrolled as the dependent, partner/spouse or principal in an employer or government-sponsored insurance plan. Additionally, the plan must meet minimum standards for coverage as set forth below:

- It must offer at least 75% coverage for inpatient and outpatient medical services in the Pittsburgh area.
- It must include mental health benefits.
- The deductible must not exceed \$500 per accident or illness.
- It must offer medical benefits of at least \$50,000 per accident or illness.
- It must cover pre-existing conditions.

Contact

Questions should be directed to Student Health Services, (412) 268-2157.

Carnegie Mellon Freedom of Expression Policy

Freedom of Expression Policy

Carnegie Mellon University values the freedoms of speech, thought, expression and assembly - in themselves and as part of our core educational and intellectual mission. If individuals are to cherish freedom, they must experience it. The very concept of freedom assumes that people usually choose wisely from a range of available ideas and that the range

and implications of ideas cannot be fully understood unless we hold vital our rights to know, to express, and to choose. The university must be a place where all ideas may be expressed freely and where no alternative is withheld from consideration. The only limits on these freedoms are those dictated by law and those necessary to protect the rights of other members of the University community and to ensure the normal functioning of the University.

Rights

On Carnegie Mellon's Campus, anyone may distribute printed material, offer petitions for signature, make speeches, and hold protests or demonstrations outside university buildings. All such activities must be peaceful, avoiding acts or credible threats of violence and preserving the normal operation of the university. No event shall infringe upon the rights or privileges of anyone not in sympathy with it, and no one will be permitted to harm others, damage or deface property, block access to university buildings or disrupt classes. The enforcement of these conditions will not depend in any way on the message or sponsorship of the act or event. When guests are invited by a recognized campus organization, they may express their ideas not because they have a right to do so, but because members of the campus community have a right to hear, see, and experience diverse intellectual and creative inquiry. Defending that right is a fundamental obligation of the university. Controversy cannot be permitted to abridge the freedoms of speech, thought, expression or assembly. They are not matters of convenience, but of necessity.

Responsibilities

Freedom of expression must be at once fiercely guarded and genuinely embraced. Those who exercise it serve the Carnegie Mellon community by accepting the responsibilities attendant to free expression. University organizations that sponsor invited guests to campus are expected to uphold Carnegie Mellon's educational mission by planning carefully to create safe and thoughtful experiences for those involved. Hosts are responsible for the behavior of their guests and should exercise due care to ensure that all participants abide by relevant university policies.

Considerations for Planning Campus Events

Consistent with the rights and responsibilities outlined in the university's policy on Freedom of Expression, university hosts must follow all applicable policies related to space reservation, use, safety and security, keeping in mind the responsibility to have campus police present for any event with 100 or more persons in attendance.

Hosts should consider the items below as guidance in planning campus events, recognizing that not all of the items will apply to all events:

1. A public declaration of the event, its purpose, the identification of sponsors and co-sponsors, and contact information for those seeking further information.
2. A plan for advertising the event, including advance notice to relevant members of the community who may wish to co-sponsor, protest, or host other events in response to the planned activity.
3. Where appropriate, a clear and detailed contract with outside speakers, artists, or suppliers of services to ensure continuity of purpose and the ability of the host to control the event reasonably, consistent with the host's intent.
4. A plan for access to the event, including notifying the community of reserved seats, ticketing, queuing protocol, or other relevant details or restrictions well in advance of the activity.
5. A provision for security before, during, and after events, managed in coordination with the University Police. Specifically, non-university security personnel must have their allowable duties clearly delineated, in partnership with the University Police, with their role generally limited to personal security and not to space management.
6. A plan for participant engagement at the event, such as through a question and answer session, if relevant, with a clear delineation of the planned ground rules for the event set out well in advance.
7. A strategy for hosting of additional events, discussions, or town meetings before or after a principal event to help provide a context in which the principal event may be best experienced.

The Office of Student Activities and the Office of the Dean of Student Affairs may assist in, or directly coordinate, some aspects of campus events, such as fostering discussions preceding or following an event, or accommodating an opposing view at an alternative event. It is assumed that the spirit of community, both among people with groups with opposing views, as well as between event sponsors and the Student Activities and Student Affairs staffs, will foster communication and cooperation in the planning of campus events. Wherever possible, Student Affairs will work in concert with

University Police to notify occupants of buildings in advance of any potential disruption caused by such events.

Security Personnel Statement

At times, members of the campus community or their invited guests may have a legitimate basis for being accompanied by independent security personnel. It is incumbent upon the host of such an individual to ensure that University Police approve in advance the presence and scope of involvement of any such security personnel.

Human Subjects in Research at Carnegie Mellon

The university is committed to the protection of the rights and welfare of human subjects in research investigations conducted under the jurisdiction of the university. The university believes that review independent of the investigator is necessary to safeguard the rights and welfare of human subjects of research investigations. All research involving human subjects is conducted in accordance with federal regulations, including Title 45 of the Code of Federal Regulations, Part 46 (45 CFR 46). Under federal regulations, human subjects are defined as: living individual(s) about whom an investigator conducting research obtains:

- data through intervention or interaction with the individual, or
- identifiable private information.

An Institutional Review Board (IRB) is established under the provost to ensure adequate safeguards. The provost is responsible for the composition of the IRB with respect to: (1) the qualifications of IRB members in terms of educational background and research or other relevant experience, and (2) broad representation of relevant university interests.

This IRB is responsible for reviewing investigational procedures involving human subjects prior to the initiation of the research procedure in reference to (1) the rights and welfare of the individuals involved, (2) the appropriateness of the methods used to obtain informed consent, and (3) the risks and potential benefits of the investigations. The IRB is responsible for determining when additional expertise is required for adequate review and for obtaining that additional expertise. The IRB is further responsible for maintaining records of its review activities and decisions and for ensuring that records of informed consent are developed and kept by investigators where appropriate.

It is the responsibility of investigators who plan to use human subjects in research to obtain written consent from the IRB prior to conducting an investigation involving human subjects. It is the investigator's further responsibility to take whatever steps are determined necessary for the protection of the subjects, and to meet the reporting requirements established by the IRB.

Student Immunization Policy

Reason for Policy

Vaccine-preventable diseases continue to occur on American campuses and pose a significant threat to the public health of the campus community. Outbreaks not only impose a significant cost to infected individuals in terms of mortality and morbidity but also can be costly to the university by disrupting university activities.

Policy Statement

The goal of the Student Health Services and the university is to provide adequate protection of the campus community against vaccine-preventable diseases by requiring students to be vaccinated against and/or screened for certain highly contagious diseases. This goal can best be achieved through a mandatory prematriculation immunization requirement. The following requirements are consistent with Pennsylvania State Law and with the recommendations of the American College Health Association, the Advisory Committee on Immunization Practices.

Requirements for All Full-Time Students

All entering full-time students born after 1956 must demonstrate proof of immunity against measles, mumps and rubella by either providing dates of inoculation of two doses of the measles vaccine and at least one dose of mumps and rubella or providing blood titers that demonstrate immunity to these infections or providing documentation from a physician of having had the infection.

Additional Requirements for Students Residing in University Housing

- All students residing in university housing must demonstrate immunity against Hepatitis B by either providing documentation of having initiated or completed the three dose vaccination series.
- The student is expected to complete the series within six months of initiation of the series.
- All students residing in university housing must provide documentation of having been vaccinated against meningococcal meningitis within three years prior to enrollment in the university.
- All full-time international students must provide documentation of having had a PPD skin test to screen for tuberculosis within one year prior to enrollment in the university regardless of prior BCG inoculation. If the results of the skin test are positive, a chest x-ray is required.

Request for Waiver

- A student may request a waiver from any vaccination for medical reasons or if vaccination conflicts with personal or religious beliefs. Application for waiver is to be made in writing to Student Health Services prior to the first day of classes in his/her first semester of attendance at the university. In the case of an outbreak of a contagious disease on campus for which the student has not been immunized, the university reserves the right to ask the student to leave campus until the outbreak is over.
- A student may request a waiver from tuberculin skin testing if the student is from a country that has been identified by the Centers for Disease Control as having low prevalence of tuberculosis.

Penalty for Noncompliance

- If the student fails to comply with the immunization policy, the Student Health Services will notify Enrollment Services who will place a hold on the student's registration until the requirements are met and assess a fee of no more than \$50 to the student's account.
- Additionally, if the student is a resident in university housing and fails to comply with the immunization requirements, he/she will be removed from housing.

Contact

Questions should be directed to Student Health Services, (412) 268-2157.

Related Policies and Procedures

The university complies with OSHA regulations regarding occupational exposure to blood-borne pathogens. Questions regarding these regulations should be directed to Environmental Health & Safety, (412) 268-8182.

Additional recommendations

A PPD skin test for tuberculosis is recommended for domestic students who have traveled to an area where tuberculosis is endemic. All students should have a booster dose of tetanus/diphtheria every ten years after completion of the primary series.

Intellectual Property Policy

1. Purpose

The policy reflects the following goals:

- To create a university environment that encourages the generation of new knowledge by faculty, staff, and students.
- To facilitate wide transfer of useful inventions and writings to society.
- To motivate the development and dissemination of intellectual property by providing appropriate financial rewards to creators and the university, and administrative assistance to creators.
- To ensure that the financial return from the development of intellectual property does not distort decisions and operations of the university in a manner contrary to the mission of the university.

The policy is based upon the following principles relating the university to society:

- The mission of the university remains the generation and dissemination of knowledge.

- Intellectual property will be generated within the university, and there exists an obligation to disseminate it. An interface is needed if better technology transfer is to be achieved, and the university will provide mechanisms for that function.¹

The policy is based upon the following principles relating faculty, staff and students to the university:

- Intellectual property is created by individuals, or by groups of individuals, who are entitled to choose the course of disclosure; academic freedom of individuals is a higher priority than possible financial rewards.
- There exists a historical tradition allowing authors to retain ownership of intellectual property rights from textbooks and works of art.
- The university is the support of the whole campus community, and is thereby entitled to share in financial rewards.
- There should be incentives for all parties to pursue financial rewards together, consistent with the expressed goals of the policy. The distribution of these rewards should reflect, insofar as possible, the creative contributions of the creator, and the resources contributed by and risks assumed by both the creator and the university in developing intellectual property.
- Since it is frequently difficult to assess risks meaningfully, resources and potential rewards, negotiated agreements are to be encouraged whenever possible.

2. Definitions

Certain terms are used in this document with specific meanings, as defined in this section. These definitions do not necessarily conform to customary usage.

Intellectual Property includes any patentable invention, any copy-rightable subject matter, or trade secret. It also includes works of art, and inventions or creations that might normally be developed on a proprietary basis.

University means Carnegie Mellon.

Student means any full-time or part-time graduate or undergraduate student, regardless of whether the student receives financial aid from the university or from outside sources. It is the responsibility of students who are also employees of other outside entities to resolve any conflicts between this policy and provisions of agreements with their employers prior to beginning any undertaking at the university that will involve the development of intellectual property.

Faculty means members of the university's Faculty Organization as defined in the Faculty Handbook, plus instructors and special faculty appointments (even in the first year), and part-time faculty.

Staff means any employee of the university other than students and faculty as defined above. If a student is also a part-time university employee, he is considered as staff with regard to intellectual property developed as a result of his employment, and as a student with regard to other intellectual property. A full-time non-faculty employee who is also taking one or more courses is considered to be staff. Visitors to the university who make substantial use of university resources are considered as staff with respect to any intellectual property arising from such use. (The distinction between faculty and staff does not affect intellectual property rights except for representation on the Intellectual Property Adjudication Committee [see Section 5].)

Creator means any person or persons who create an item of intellectual property.

Net proceeds to the university means all proceeds received by the university on intellectual property that it assigns, sells or licenses, minus any application, litigation, interference, or marketing costs directly attributable to the intellectual property being licensed. Deducted costs shall be reasonable and fair, and shall be properly disclosed; the sources and amounts of compensation shall also be properly disclosed.

Net proceeds to the creator means all proceeds received by the creator from intellectual property owned by him that he sells, assigns or licenses, less the costs of application, legal protection, or litigation, interference, travel and other marketing costs directly attributable to the intellectual property being exploited. Such net proceeds do not include compensation legitimately received by the creator for consulting services or interest or other return on invested labor or capital. Deducted costs shall be reasonable and fair, and shall be properly disclosed; the sources and amounts of compensation shall also be properly disclosed.

Substantial use of university facilities means extensive unreimbursed use of major university laboratory, studio or computational facilities, or human resources. The use of these facilities must be important to the creation of the intellectual property; merely incidental use of a facility

does not constitute substantial use, nor does extensive use of a facility commonly available to all faculty or professional staff (such as libraries and offices), nor does extensive use of a specialized facility for routine tasks. Use will be considered "extensive" and facilities will be considered "major" if similar use of similar facilities would cost the creator more than \$5000 (five thousand dollars) in constant 1984 dollars if purchased or leased in the public market. Creators wishing to directly reimburse the university for the use of its facilities must make arrangements to do so before the level of facilities usage for a particular intellectual property becomes substantial. (This provision is not intended to override any other department or university policy concerning reimbursement for facilities usage.)

In general:

In any given year the equivalent figure for a particular amount of money in constant 1984 dollars will be obtained by multiplying that amount of money by the ratio of the most recent quarterly Disposable Personal Income Deflator divided by the average monthly Disposable Personal Income Deflator for the year 1984.

As used in this policy, the masculine gender includes the feminine gender, singular or plural, wherever appropriate.

3. Policy Provisions

This section states the policies concerning ownership of intellectual property created at the university. In order of precedence, ownership of intellectual property shall be as follows:

3-1. Externally Sponsored Work

Ownership Provisions: Intellectual property created as a result of work conducted under an agreement between an external sponsor and the university that specifies the ownership of such intellectual property shall be owned as specified in said agreement. If the university declares itself to be a sponsor, but does not declare itself to be the owner of the intellectual property, ownership shall be determined in accordance with 3-6-4 below.

Procedural Provisions: It is the responsibility of the Office of Sponsored Research of the university to inform each person whose intellectual property rights are limited by an externally sponsored contract of the intellectual property provisions of that contract in advance of the beginning of work thereon. Such notice is to be in writing and the university may require written acknowledgment of such provisions by any person working on externally sponsored projects. A summary of external sponsorship agreements limiting the intellectual property rights of potential creators will be maintained by the Office of Sponsored Research and will be available to the general university community.

If the university fails to notify a creator, effectively and in advance, of limitations imposed on his intellectual property rights by external sponsorship agreements, the creator is entitled to receive from the university 50% (fifty percent) of the net proceeds to the university resulting from his intellectual property.

3-2. Internally Sponsored Work

Ownership Provisions: When the university provides funds or facilities for a particular project to the extent of substantial use, it may also choose to designate itself as sponsor of that work. The university may declare itself the owner of intellectual property resulting from said work. In such cases the university must specify in advance the disposition of any intellectual property rights arising from the project. If the university declares itself to be a sponsor, but does not declare itself the owner of the intellectual property, ownership shall be determined in accordance with 3-6-4 below.

Procedural Provisions: It is the responsibility of the Office of Sponsored Research of the university to inform each person whose intellectual property rights are limited by internally sponsored work of the intellectual property ownership rights specified by the university as to that work in advance of the beginning of work thereon. Such notice is to be in writing and the university may require written acknowledgment of such provisions by any person working on internally sponsored projects. A summary of work for which university sponsorship limits the intellectual property rights of potential creators will be maintained by the Office of Sponsored Research and will be available to the general university community.

If the university fails to notify a creator, effectively and in advance, of limitations imposed on his intellectual property rights by internal university sponsorship, the creator is entitled to receive from the university 50% (fifty percent) of the net proceeds to the university resulting from his intellectual property.

3-3. Individual Agreements

Ownership Provisions: Intellectual property which is the subject of a specific agreement between the university and the creator(s) thereof shall be owned

as provided in said agreement. Such agreements by the university and the faculty are encouraged.

Procedural Provisions: Except where limited by external sponsorship agreements, creators and the university may negotiate individual agreements to govern ownership of intellectual property regardless of the applicability of any other provision hereof.

3-4. Intellectual Property Created Within Scope of Employment

Ownership Provisions: Intellectual property created by university employees who were employed specifically to produce a particular intellectual property shall be owned by the university if said intellectual property was created within the normal scope of their employment. Faculty are presumed not to be hired to produce a particular intellectual property. On the other hand, computer programs written on the job by staff computer programmers would fall under this provision.

3-5. Public Dedication

Ownership Provisions: Except when limited by sub-parts 3-1, 3-2, 3-3 or 3-4 above, the creator of any intellectual property may choose to place his or her creation in the public domain. In such cases both the creator and the university waive all ownership rights to said property.

Procedural Provisions: Creators wishing to place their intellectual property in the public domain are responsible for ascertaining that the right to public dedication of that intellectual property is not limited by any external agreement, university sponsorship arrangement or terms of employment as described in Provisions 3-1, 3-2 or 3-3. The university provost will provide such a determination in writing upon request by the creator. It is also the creator's responsibility to ensure that disclosure does not include valuable intellectual property owned by others. (This provision does not release the university from its general obligation to notify creators of limitations to intellectual property rights specified in Provisions 3-1 and 3-2.)

To facilitate the actual transfer of knowledge of the intellectual property to the public at large, the creator shall provide the university with a complete description and documentation of the property placed in the public domain, specifically including a copy of the property in the case of printed material, and complete machine-readable source code in the case of software. All such material provided to the university will be placed in the University Library and made available to the public at large. The university will take appropriate action on a regular basis to publicize summary descriptions of intellectual property recently placed in the public domain. The university will also provide any member of the general public copies of such material on a cost-recovery basis.

The provisions of this section do not apply to the normal scholarly or creative publication processes unless the creator intends to waive all proprietary rights to the publication.

3-6. In General

Unless governed by sub-parts 3-1, 3-2, 3-3, 3-4 or 3-5 above, ownership of intellectual property created at the university shall be determined as follows:

3-6-1. Traditional Rights Retained

Ownership Provisions: In keeping with academic traditions at the university, the creator retains all rights to the following types of intellectual property, without limitation: books (including textbooks), educational course-ware, articles, non-fiction, novels, poems, musical works, dramatic works including any accompanying music, panto-mimes and choreographic works, pictorial, graphic and sculptural works, motion pictures and other similar audio-visual works, and sound recordings, regardless of the level of use of university facilities. This provision does not include computer software (other than educational course-ware) or data bases.

Procedural Provisions: The types of intellectual property listed in the preceding paragraph share the attribute that they display information or visual or auditory appearances which are fully revealed to the purchaser or consumer. Thus, for example, source code listings would also be considered within this category. On the other hand, most computer software and data bases do not share this attribute; they are characterized by their capacity to perform tasks. Because of their utilitarian nature, ownership rights with respect thereto are governed by 3-6-3 or 3-6-4. Educational course-ware is included in this provision in all cases because of its role in furthering the primary educational mission of the university.

This provision applies regardless of any university sponsorship of the work, and it may be modified only by a specific prior agreement between the creator and the university. The use of university-owned computers and other facilities in the preparation of books and similar works does not alter this provision, though other university policies may limit such use or require reimbursement to the university. Similarly, the use of externally sponsored

resources does not alter this provision, unless the creator is effectively notified in advance of such limitations to his rights in accordance with 3-1.

3-6-2. No Substantial Use of University

Facilities Ownership Provisions: The creator owns all intellectual property created without substantial use of university facilities, including intellectual property rights in computer software and data bases.

3-6-3. Substantial Use of University Facilities - No External or Internal Sponsorship

Ownership of intellectual property created with substantial use of university facilities, but not directly arising from externally sponsored work, or from work for which the university has declared itself as sponsor, shall be determined as set forth hereinafter depending on whether the creator or the university develops said property.

3-6-3-1. Development by Creator

Ownership Provisions: The creator originally owns intellectual property created with substantial use of university facilities but no external or internal sponsorship, and retains said ownership by commercial development of said property subject to the following:

(i) the university shall receive 15% (fifteen percent) of the net proceeds to the creator above \$25,000 (twenty-five thousand dollars) in constant 1984 dollars from all sources (in the case of patents and copyrights, this provision shall be limited to the life of the patent or copyright), and

(ii) the university shall receive a perpetual, non-exclusive, non-transferable, royalty free license to use said intellectual property. In the case of software, this license includes access by specified university personnel to the source listings, and the university shall require each person to whom a disclosure is made to execute in advance a binding confidentiality agreement in favor of and enforce-able by the creator. If the intellectual property is created solely by a student or students, the creator is exempt from the obligation to pay to the university a fraction of his net proceeds, but not from the provision of this paragraph for a non-exclusive license to the university.

Procedural Provisions: If the creator develops an intellectual property that is covered by this provision, he must make full and fair disclosure to the university of all such sources of compensation relating to that intellectual property.

3-6-3-2. Development by the University

Ownership Provisions: When intellectual property is created with substantial use of university facilities, but not directly arising from sponsored research, the creator will originally retain the rights to the property, provided that he desires to commercially develop the property himself or to make it available to the public. If, however, the creator elects not to commercially develop same or fails to show diligence in pursuing such development, then the ownership rights to that property may be acquired by the university. Intellectual property acquired by the university in this fashion will be treated as in 3-6-4-1 below.

Procedural Provisions: At the time the intellectual property is disclosed to the university's provost as required under Section 4-1, or at any time thereafter, the university may request that the creator decide whether he will develop the intellectual property or will grant the rights to the university, and execute documents to pass on the title. Such a decision must be made within one year of the request or the creator will automatically lose his rights in favor of the university.

3-6-4. Substantial Use of University Facilities - External or Internal Sponsorship

Ownership of intellectual property created with substantial use of university facilities and directly arising from work sponsored under an agreement between an external sponsor and the university, or from work for which the university has declared itself a sponsor, but for which neither the external sponsor nor the university have specified the ownership of resulting intellectual property shall be determined as set forth hereinafter depending on whether the creator or the university develops said property.

3-6-4-1. Development by University

Ownership Provisions: The university originally owns intellectual property created with substantial use of university facilities provided by an external agreement or internal university sponsorship and retains said ownership by commercial development of said property, subject to the following: in all cases, the creator shall receive 50% (fifty percent) of the net proceeds to the university.

Procedural Provisions: When an intellectual property is created with substantial use of university resources provided by an external research contract or a specific university sponsorship agreement, and when that

contract or agreement either does not specify the disposition of the intellectual property rights arising from that sponsorship, or it permits the university and/or creator to retain or acquire such intellectual property rights, the university will originally retain the rights to such intellectual property.

3-6-4-2. Development by Creator

Ownership Provisions: When intellectual property is created with substantial use of university facilities provided by external or internal sponsorship, the university will originally retain the rights to the property, provided that it desires to commercially develop the property or to make it available to the public. If, however, the university elects not to commercially develop same or fails to show diligence in such development, the ownership rights to that property may be acquired by the creator. Intellectual property acquired by the creator in this fashion will be treated as in 3-6-3-1 above. This assignment of rights to the creator may be prohibited by the terms of an external sponsorship agreement with the university or by an internal university sponsorship declaration, but in such cases the creator must be notified in advance, as in Provisions 3-1 and 3-2.

Procedural Provisions: At the time the intellectual property is disclosed to the university's provost as required by Section 4-1, or at any time thereafter, the creator may request that the university decide whether it will commercially develop the intellectual property or execute an assignment of the intellectual property rights to the creator. Such a decision must be made within 120 (one hundred twenty) days of the request or the university automatically waives its rights in favor of the creator, and it must execute an assignment of these rights to the creator.

3-6-5. Consulting Agreements

Ownership Provisions: Work done by individuals as consultants to outside firms is presumed not to involve unreimbursed substantial use of university facilities, and the rights to intellectual property created under consulting agreements are retained by the outside firms or the individual as specified by the terms of the consulting agreement and the terms of Provision 3-6-2 above.

Procedural Provisions: Under university policy consulting work must not make substantial unreimbursed use of university facilities except by explicit prior agreement. Any member of the university community who is engaged in consulting work or in business is responsible for ensuring that provisions in his agreements are not in conflict with this policy of the university or with the university's commitments. The university's Innovation Transfer Office will, upon request, provide assistance in this respect. The university's rights and the individual's obligations to the university are in no way abrogated or limited by the terms of such agreements. Each creator of intellectual property should make his obligations to the university clear to those with whom he makes such agreements and should ensure that they are provided with a current statement of the university's intellectual property policy. Appropriate sample contract wording to cover various possible external consulting arrangements shall be available from the university provost.

4. General Procedures

4-1.

The creator of any intellectual property that is or might be owned by the university under this policy is required to make reasonably prompt written disclosure of the work to the university's provost, and to execute any document deemed necessary to perfect legal rights in the university and enable the university to file patent applications and applications for copyright registration when appropriate. This disclosure to the provost should be made at the time when legal protection for the creation is contemplated, and it must be made before the intellectual property is sold, used for profit, or disclosed to the public. Whenever legal protection for intellectual property is anticipated all persons engaged in such creative activity are encouraged to keep regular notebooks and records.

4-2.

Whenever the university undertakes commercial development it shall do so, if possible, in a fashion that provides for the widest possible dissemination, avoiding suppression of inventions from which the public might otherwise benefit, providing for non-exclusive licensing at reasonable royalties, and giving consideration to more favorable or royalty-free licensing to non-profit charitable institutions, minority businesses or enterprises in developing countries.

4-3.

The university's share of any proceeds under this policy will be used to reimburse the university for its expenses for commercial development of intellectual property. Any additional return to the university will be used to further the academic purposes of all the disciplines of the entire university.

5. Resolution of Disputes

This policy constitutes an understanding which is binding on the university and on the faculty, staff, and students upon whom it is effective according to the terms of Section 6 below, as a condition for participating in research programs at the university or for the use of university funds or facilities.

Any question of interpretation or claim arising out of or relating to this policy, or dispute as to ownership rights of intellectual property under this policy, will be settled by the following procedure:

- The issue must first be submitted to the university's Intellectual Property Adjudication Committee in the form of a letter setting forth the grievance or issue to be resolved. The committee will review the matter and then advise the parties of its decision within 60 days of submission of the letter.
- If any of the parties to the dispute is not satisfied with the committee's decision, the party may seek binding arbitration in Pittsburgh, Pennsylvania and in accordance with the Rules of the American Arbitration Association then in effect. Judgment upon the award rendered by the arbitrator(s) may be entered in any court having jurisdiction thereof. The arbitrator(s) will give some weight to the decision of the Intellectual Property Adjudication Committee in reaching a decision. The losing party of the arbitration hearing will pay for all costs of the arbitration unless the arbitrator(s) specifies otherwise.

The Intellectual Property Adjudication Committee will consist of a chair who is a member of the tenured faculty, four other members of the faculty, and four other members representing, respectively, the university administration, the technical staff, and the graduate and undergraduate student bodies. Initially, half of the members of the committee (including the chair) will be appointed for two-year terms of office, and the remaining half will be appointed for a one-year term. After one year new members of the committee will be appointed for two-year terms of office. The chair will be appointed by the chair of the Faculty Senate, with the advice and consent of the Faculty Senate Executive Committee, and the remaining eight members of the committee will be appointed by the president of the university or his designee. At all times at least one of the faculty members will have had significant practical experience with intellectual property development and exploitation. The faculty members appointed by the president of the university will be selected from a list of nominees prepared by the Faculty Senate or its designated committee and nominees with experience in intellectual property development will be identified as such by the Faculty Senate. The staff representative will be selected from a list of nominees prepared by Staff Council, and the administration representative will be named directly by the president of the university or his designee. The graduate student representative will be selected from a list of nominees prepared by the Graduate Student Organization. The undergraduate representative will be chosen from a list of nominees prepared by the Student Senate. The committee will use the guidelines set forth in this policy to decide upon a fair resolution of any dispute.

If possible, the committee will also provide on request informal advisory opinions to creators and the university indicating how it is likely to interpret the provisions of this policy as it applies to special cases.

6. Effective Date of Policy

This policy will become effective August 27, 1985. Once effective this policy will be binding on new faculty, administration, and staff when hired, and on graduate and undergraduate students when admitted. Current faculty and staff will also become bound by this policy when they sign new employment contracts as the result of the renewal of limited-term appointments or promotion. Other university personnel, including tenured faculty, and current staff and students may choose to become bound by this policy for future and pending intellectual property by voluntary written consent. Unless the creator and the university agree to a different arrangement, intellectual property that is already partially developed at the time this policy becomes effective will be treated according to the provisions of the patent policy by which the University creator is currently bound. Similarly, members of the university working under contracts signed before the effective date of this policy who do not choose to accept this policy will remain bound by the patent policies that already apply to them. With respect to intellectual property developed during the course of employment at the university, this policy shall continue to be binding on any person whose relationship with the university becomes terminated. The university should take all administrative steps necessary to ensure that employees and students sign, upon initial employment, registration or at other appropriate times, forms that indicate their acceptance of this policy.

7. Amendments of the Policy

Amendments of this policy may be proposed by the Faculty Senate, Staff Council or university administration. Proposed amendments must be approved by a two-thirds majority of votes in the Faculty Senate and subsequently approved by a simple majority of votes cast in a referendum

administered by the Faculty Senate that is open to all members of the faculty as defined by this policy and to the exempt staff, provided that this majority constitutes at least 25% (twenty-five percent) of those eligible to vote. This referendum must be preceded by an opportunity for public discussion open to all interested faculty, administration, staff and students. Amendments that are supported by the faculty and staff must then be approved by the president of the university and adopted by the university trustees. Once adopted, amendments will become binding on new faculty, administration, and staff when hired, on existing faculty and staff when they sign new employment contracts, and on graduate and undergraduate students when admitted. Other university personnel, including tenured faculty, and current staff and students may choose to become bound by this policy for future and pending intellectual property by voluntary written consent. Intellectual property that is already developed or under development at the time that an amendment to the policy is ratified will not be bound by the terms of the amendment without the voluntary written consent of both the creator and the university.

Footnote:

1. This document presumes the existence of a university office to facilitate technology transfer. Such an office would serve as a clearinghouse for contacts with outside partners, would perform patent and copyright tasks, and would develop an effective marketing capability.

Policy on Student Privacy Rights

Policy Statement

Under the Family Educational Rights and Privacy Act (FERPA), you have the right to:

- Inspect and review your education records;
- Request an amendment to your education records if you believe they are inaccurate or misleading;
- Request a hearing if your request for an amendment is not resolved to your satisfaction;
- Consent to disclosure of personally identifiable information from your education records, except to the extent that FERPA authorizes disclosure without your consent;
- File a complaint with the U.S. Department of Education Family Policy Compliance Office if you believe your rights under FERPA have been violated.

1. Inspection

What are education records?

Education records are records maintained by the university that are directly related to students. These include biographic and demographic data, application materials, course schedules, grades and work-study records. The term does not include:

- Information contained in the private files of instructors and administrators, used only as a personal memory aid and not accessible or revealed to any other person except a temporary substitute for the maker of the record;
- Campus Police records;
- Employment records other than work-study records;
- Medical and psychological records used solely for treatment purposes;
- Records that only contain information about individuals after they have left the university;
- Any other records that do not meet the above definition of education records.

How do I inspect my education records?

- Complete an Education Inspection and Review Request Form (available online as a PDF document or from The HUB, 12C Warner Hall) and return it to The HUB.
- The custodian of the education record you wish to inspect will contact you to arrange a mutually convenient time for inspection, not more than 45 days after your request. The custodian or designee will be present during your inspection.
- You will not be permitted to review financial information, including your parents' financial information; or confidential letters of recommendation, if you have waived your right to inspect such letters.

- You can get copies of your education records from the office where they are kept for 25 cents per page, prepaid.

2. Amendment

How do I amend my educational records?

- Send a written, signed request for amendment to the Vice President for Campus Affairs, Carnegie Mellon University, 610 Warner Hall, Pittsburgh, PA 15213. Your request should specify the record you want to have amended and the reason for amendment.
- The university will reply to you no later than 45 days after your request. If the university does not agree to amend the record, you have a right to a hearing on the issue.

3. Hearing

How do I request a hearing?

- Send a written, signed request for a hearing to the Vice President for Campus Affairs, Carnegie Mellon University, 610 Warner Hall, Pittsburgh, PA 15213. The university will schedule a hearing no later than 45 days after your request.
- A university officer appointed by the Vice President for Campus Affairs, who is not affiliated with your enrolled college will conduct the hearing.
- You may bring others, including an attorney, to the hearing to assist or represent you. If your attorney will be present, you must notify the university ten days in advance of the hearing so that the university can arrange to have an attorney present too, if desired.
- The university will inform you of its decision, in writing, including a summary of the evidence presented and the reasons for its decision, no later than 45 days after the hearing.
- If the university decides not to amend the record, you have a right to add a statement to the record that explains your side of the story.

4. Disclosure

Carnegie Mellon generally will not disclose personally identifiable information from your education records without your consent except for directory information and other exceptions specified by law.

What is directory information?

Directory information is personally identifiable information of a general nature that may be disclosed without your consent, unless you specifically request the university not to do so. It is used for purposes like compiling campus directories.

If you do not want your directory information to be disclosed, you must notify the University Registrar's Office in writing within the first 15 days of the semester.

Notifying the University Registrar's Office covers only the disclosure of centralized records. Members of individual organizations such as fraternities, sororities, athletics, etc. must also notify those organizations to restrict the disclosure of directory information.

Carnegie Mellon has defined directory information as the following:

- your full name,
- local/campus address and local/campus telephone number,
- email User ID (Andrew ID) and address,

(User IDs cannot be completely suppressed from our electronic systems. While it may be possible to suppress the association of an individual's name with their user id, doing so may adversely impact the delivery of electronic mail or other electronic services.)

- major, department, college,
- class status (freshman, sophomore, junior, senior, undergraduate or graduate)
- dates of attendance (semester begin and end dates),
- enrollment status (full, half, or part time)
- date(s) of graduation,
- degree(s) awarded,
- sorority or fraternity affiliation.

For students participating in intercollegiate athletics, directory information also includes:

- height, weight
- sport of participation.

What are the other exceptions?

Under FERPA, Carnegie Mellon may release personally identifiable information from your education records without your prior consent to:

- school officials with legitimate educational interests ("School officials" are Carnegie Mellon employees in administrative, supervisory, academic or support staff positions; Carnegie Mellon trustees; individuals and companies with whom the university has contracted, such as attorneys, auditors, or collection agencies; and individuals assisting school officials in performing their tasks. School officials have a "legitimate educational interest" if they need to review an education record in order to fulfill their professional responsibilities.);
- certain federal officials in connection with federal program requirements;
- organizations involved in awarding financial aid;
- state and local officials who are legally entitled to the information;
- testing agencies such as the Educational Testing Service, for the purpose of developing, validating, researching and administering tests;
- accrediting agencies, in connection with their accrediting functions;
- parents of dependent students (as defined in section 152 of the Internal Revenue Service Code);
- comply with a judicial order or subpoena (after making a reasonable effort to notify the student in advance of compliance so that the student can take protective action, except in cases where the university is legally required not to disclose the existence of the subpoena);
- appropriate parties in a health or safety emergency, if necessary to protect the health or safety of the student or other individuals;
- officials of another school in which the student seeks or intends to enroll;
- victims of violent crimes or non-forcible sexual offenses (the results of final student disciplinary proceedings);
- parents or legal guardians of students under 21 years of age (information regarding violations of university drug and alcohol policies);
- courts (records relevant to legal actions initiated by students, parents or the university).
- comply with federal laws concerning sex offenders and other individuals required to register under section 170101 of the Violent Crime Control and Law Enforcement Act of 1994.

5. Complaints

If you believe the university has not complied with FERPA, you can file a complaint with the:

Family Policy Compliance Office, Department of Education, 400 Maryland Avenue, S.W. Washington, DC 20202-4605

Policy on Restricted Research

Universities have two primary purposes: to create knowledge and to disseminate knowledge. Carnegie Mellon University recognizes the importance of open intellectual communication within a research group, within the university, and within the larger community outside. Ideally, all units of the university would disseminate the results of research as quickly and as widely as possible. Some members or units of the university, however, desire to do research that may be difficult or impossible without restrictions or without access to classified or proprietary materials.

There exists, therefore, a tension between the university's goal of disseminating knowledge freely and the desire on the part of some of its members to conduct restricted research on important problems. The university intends to guarantee the academic freedom of all faculty members to do research in their own manner on topics of their own choosing, provided that such research is consistent with the overall purposes of the university.

This policy seeks to resolve the tension between the desire to participate in restricted research and the desire to maintain the open atmosphere of the university by confining restricted research to semi-autonomous units, which are not associated with any academic departments. It thereby establishes the principle that restricted research is inappropriate at Carnegie Mellon University except in the semi-autonomous units.

This policy does not attempt to anticipate all possible concerns about restricted research. In some cases, decisions will need to be made about particular research projects to which the application of particular policy guidelines are not clear. In choosing to accept or decline such projects, the university will weigh the potential of a project for generating and disseminating new knowledge for the benefit of society, against the project's potential for adversely affecting the climate for research conducted in a free and open environment. While this policy sets no explicit limits on the extent of classified research permitted in the semi-autonomous units, it is not the intent of the policy to encourage any unit of the university to engage in classified research as a primary ongoing activity. Indeed, it is expected that classified projects will never represent more than a small fraction of the total research effort in any unit.

Definitions

Research: all projects and investigations involving the creation of new knowledge of a theoretical or practical nature. The term "research" as used here encompasses both "research" and "development" as they are commonly defined.

Classified research: research, the free dissemination of the results of which is deemed to jeopardize national security. The federal government controls access to the environment in which such research is performed, restricts discussions about the work in progress to individuals with clearance and a "need to know," and limits publication of research, results or access to data needed to verify results, for a specified period of time.

Proprietary research: research that results in intellectual property that is owned by entities other than Carnegie Mellon University. Such entities may wish to market products derived from inventions or ideas that are developed at the university. They might, therefore, desire to fund projects which restrict access to data and to discussions about work in progress to individuals with a "need to know," and to seek, for a specified period of time, a delay in publication of research results or data needed to verify results. Such entities may also provide access to proprietary material, which researchers must agree not to include in publications.

Publication: oral or written dissemination.

Restricted research: includes all classified research, and any proprietary or other research that requires more than a six month delay in publication of the research results.

Semi-autonomous units: units of the university specifically so designated by the president, after consultation with the URC and the Faculty Senate, currently the Mellon Institute and the Software Engineering Institute.

Non-autonomous units: all university entities other than semi-autonomous units.

Restricted Research in Non-Autonomous Units

It is the policy of Carnegie Mellon that restricted research is inappropriate and, therefore, not permitted within its non-autonomous units.

It is also the policy of Carnegie Mellon not to permit involvement of students in projects which carry restrictions that may impede their progress toward a degree. Therefore, students should not be involved in contracts that require the delay of a student's publication of research results when such results are intended for use in obtaining academic credit, except that a sponsor may require a delay of thirty days for review of publications for removal of proprietary information that was provided by the sponsor for the conduct of the research.

Proprietary research is allowed within non-autonomous units provided it is subject to limitations (excluding students' publications as noted above) no more stringent than the following:

- A sponsor may request a delay of up to six months in publication so that steps may be taken to secure intellectual property rights to inventions or ideas developed under the contract.
- A sponsor may require a delay of thirty days for review of publications for removal of proprietary information which was provided for the conduct of the research.

Considerations for faculty/researchers:

The university recognizes that problems arise in both restricted research and research that is not itself restricted but that involves access to classified or proprietary information or materials (hereinafter, restricted materials). Researchers may also have access to restricted materials when serving as consultants. Access to restricted materials gives rise to concerns about limitations on researchers' freedom to communicate. In such instances, researchers must exercise consider-able judgment to conduct their research in an open environment while protecting the restricted materials to which they have access. Researchers must also be aware that the university will judge their performance as researchers through their publications or

through other scholarly products that arise from their research. Research that is restricted in dissemination, or not available for public review, cannot be considered in promotion or reappointment decisions or in evaluations of academic performance of any kind.

Considerations for faculty/researchers:

There are important concerns about the involvement of students in restricted research. It is necessary for students to publish their work in order to obtain degrees, course credit and professional recognition. Students rely to a large degree on their faculty advisor's judgment for guidance and advice. Research that is restricted in dissemination, or not available for public review, cannot be used for academic credit. Thus, before working on such research, a student must be notified in writing that work on this research may not be used for academic credit.

Restricted Research in Semi-Autonomous Units

The semi-autonomous units associated with Carnegie Mellon may conduct restricted research.

Faculty members may conduct restricted research in or in cooperation with semi-autonomous units only on a consulting basis or by means of a formal, internal leave of absence from their non-autonomous units.

Work that is restricted in any way may not be used for academic evaluations until it is released for publication, and then only with respect to future academic actions.

Students may occasionally be employed by the semi-autonomous units, provided that such employment does not interfere substantially with progress toward a degree. However, they must be made aware that work that is restricted cannot be used for academic credit. Work that was restricted and is later released for dissemination and review can be applied toward future academic credit. Students should be discouraged from working on restricted research in which dissemination may be delayed indefinitely.

Guidelines for all Units

Work by students on restricted research projects shall not be made a condition for admission or financial aid.

The principal investigator is responsible for informing all members of a project (faculty, staff and students) of any restrictions imposed on the dissemination of information related to the research. This must be done prior to the start of the project or prior to an individual joining an existing project.

Restrictions on access to university facilities due to the conduct of restricted research must be kept to a minimum. Access to and movement through the facilities in which restricted research is conducted must be consistent with standard university procedures.

The Provost's Office is responsible for obtaining signed documents from principal investigators on restricted research projects attesting that they are aware of all restrictions imposed on the research and that they have informed all participants of these restrictions.

The Office of Sponsored Research shall review all proposals and contracts prior to approval for conformity with these guidelines. Any that do not meet these guidelines will be referred to the University Research Council (URC) for review and recommendation of appropriate action to the provost.

To maintain a balance with the university's goals of broad dissemination of knowledge, the URC will conduct an annual review of all restricted research being conducted at the university. This review will be made based on a listing of all contracts that involve restricted research. This listing shall include the title and sponsor(s) of the research, name(s) of principal investigator(s), and the amount of funding of each contract.

The university community will be informed annually, through the URC's written report to the Faculty Senate and Student Senate, of the nature and overall impact of restricted research at Carnegie Mellon.

Existing sponsored research projects shall be allowed to continue under the terms of their present contract. However, renewal contracts must conform with this policy.

Student Activities Fee

By action of the Board of Trustees, a required Student Activities Fee in addition to tuition is charged to all under-graduate students and graduate students who enroll for 19 units or more. Student Government is responsible for administering the fee and for using it only for the support of projects under the following guidelines:

1. Activities and facilities which can be described as meeting the reasonably predictable social, cultural, recreational, or welfare needs of college students.
2. Publications which can reasonably be presumed to serve the needs of the student community for communication, expressions of opinion, and the conduct of their business.
3. Such enterprises of an entrepreneurial nature undertaken by the student body as can reasonably be expected to serve as an instrument for meeting the needs described above.

All functions and services provided by the fees described above must be in accordance with Carnegie Mellon's policy of non-discrimination. In addition, no use of such fees may be intended to violate or circumvent the policies of the university or the laws of the land.

Final responsibility for establishing the amount of any required fee rests with the Board of Trustees, which will consider changes only upon requests of the Student Government and the officers of the university.

Note: Historically, the Student Government has dedicated a specific portion of graduate students' activities fees to the Graduate Student Assembly to be used at their discretion.

Policy on Temporary Emergency Closing of the University

Policy Statement

Carnegie Mellon University has an important commitment to students, parents, sponsors, benefactors and the community. Accordingly, the university will make every attempt to operate normally during severe weather or other emergencies. This includes holding classes, conducting research programs, and operating facilities and services. The university will attempt to operate normally unless such operation represents a clear danger to students, staff or faculty.

There may be occasions when the university community is served best by suspending normal operations. In that event, only the president (or the president's designated representative) has the authority to close the university and to specify those persons or group of persons who are free to leave or refrain from coming to campus. Staff members who provide primary services, including certain members of Physical Plant, Dining Services and Security, may be asked to work.

Standard Operations

Unless the president announces that the university is closed, everyone is expected to be at work as usual. When the university is in session, faculty members are expected to meet their scheduled classes and other obligations. If a faculty member is unable to meet a scheduled class, he or she should notify the department office and arrange either for a qualified substitute or for a future make-up session.

If the university is open but a staff member is unable to come to work because of severe weather or other emergency, he or she should notify the supervisor as soon as possible. Staff members will be expected to make up lost time or use Paid Time Off (PTO), consistent with regular operating protocols.

Announcement of Closing

As soon as the president or his/her designee determines that the university must be closed, University Relations will alert local radio and television stations. Also, announcements of closings will be posted on the Carnegie Mellon electronic bboard official.cmu-news.

Contact

Questions concerning this policy or its intent should be directed to the Office of the President, (412) 268-2200.

Student Leave Policy

www.cmu.edu/policies/documents/StLeave.html

Students must sometimes interrupt their studies for a variety of reasons (financial, academic or personal). Students choosing to take a leave of absence should first contact their department advisor to discuss their plans while on leave and to work out any conditions that may be necessary for a smooth return to Carnegie Mellon.

A student may leave Carnegie Mellon by either withdrawing from the university (leaving the university with no intention of returning) or by taking

a leave of absence (leaving the university temporarily, with the firm and stated intention of returning).

A Leave of Absence Form must be completed by all students requesting a leave. A Withdrawal Form must be filled out by all students who are withdrawing. Notifying instructors and no longer attending classes does not complete the process. Forms are available in the academic departments, deans' offices and on The HUB website. Not completing the form results in tuition being charged to the midpoint of the semester or the last date the student attended an academically-related activity such as an exam, tutorial or study group, or the last day a student turned in a class assignment.

Students are required to fill out all information on the form, including all comment sections relating to reasons for their leave. After completing the form, students must take it to their home department and dean's office for appropriate signatures. The process of taking a leave will not be complete until all necessary signatures are on the leave form. Under certain circumstances, students may also need the Dean of Student Affairs to sign the appropriate form. Nonresident alien students must consult the Office of International Education for information on possible visa implications prior to going on leave.

Students on leave are not permitted to live in university housing or attend classes or maintain employment as students at Carnegie Mellon while their leave is in effect.

Doctoral candidates under ABD status (All But Dissertation) who wish to take a leave of absence should refer to the ABD and In Absentia policy.

Leaves during the academic semester will take effect as of the date signed by the student's dean. After the Leave of Absence or Withdrawal Form is received by Enrollment Services, it will be reviewed for appropriate tuition refunds (see Enrollment Services: Tuition and Fees Adjustment Policy) and grade implications. The recording of student courses and grades for taking a leave in a semester follows the deadlines for semester or mini courses, as follows:

- All courses or grades are removed, on or before the university deadline to drop classes with W (withdrawal) grades.
- W (withdrawal) grades will be assigned to all classes (for undergraduate students, and to graduate students only in Tepper School of Business or the Mellon College of Science.), after the university deadline to drop classes but before the last day of classes:
- Permanent grades assigned by the instructor will be recorded, after the last day of classes.

Contact

Questions concerning this policy or its intent should be directed to: The HUB, (412) 268-8186.

Student Return Policy

<http://www.cmu.edu/policies/documents/StReturns.html>

Policy Statement

Students on leave wishing to return to Carnegie Mellon to resume their degree studies may do so under several conditions. In order to be considered for return from leave, a student must first obtain a Return from a Leave of Absence form from The HUB or their academic department. This application requires information from the student regarding the intended semester of return, current address information and information about their leave. This application must be submitted to their home department at least one month prior to the beginning of the semester.

Undergraduates may return within their same academic department within two years. After two years, students returning in the same academic department are subject to space constraints and academic performance review. Graduate students must negotiate their return with their home department and must follow their department policy.

The Return from Leave of Absence form requires approval of the student's academic department and Dean. If a student's department chooses to deny the student's Return from Leave of Absence form, the student may appeal to their Dean. Any constraints governing the student's eligibility to return will be specified directly on the application by the academic department and/or Dean's office or the Office of Student Affairs.

Students who have taken courses elsewhere must submit an official transcript and course descriptions with their Return from Leave of Absence form. Transfer credit approval is determined by the academic department based on course level, performance and appropriateness to the student's curriculum requirements. Credit transfer is subject to college-specific policy. Failure to submit the necessary documents at the time of return will result in denial of transfer credit.

The process of returning is not completed until all necessary signatures on the Return form are obtained by the student and until all outstanding bills are paid. Enrollment Services will then notify the appropriate university offices of the student's return.

Contact

Questions concerning this policy or its intent should be directed to: The HUB, (412) 268-8186.

Tuition Adjustment Policy

www.cmu.edu/policies/documents/TuitionRefund.html

Application

This policy applies to withdrawals and leaves of absence by all students (graduate, undergraduate, non-degree) for all semesters (Fall, Spring, Summer 1, Summer 2, Summer All).

Official Date of Withdrawal/Leave of Absence

For students who notify the university of their intent to withdraw or take a leave of absence, the official date of withdrawal or leave of absence is the earliest of:

- the date the student began the withdrawal or leave of absence process;
- the date the student notified his or her home department;
- the date the student notified the associate dean of his or her college; or
- the date the student notified the dean of students.

For students who do not notify the university of their intent to withdraw or take a leave of absence, the official date of withdrawal or leave of absence is:

- the midpoint of the semester;
- the last date the student attended an academically-related activity such as an exam, tutorial or study group, or the last day a student turned in a class assignment.

Tuition Adjustment

Students who withdraw or take a leave of absence before completing 60% of the semester will be charged tuition based on the number of days completed within the semester. This includes calendar days, class and non-class days, from the first day of classes to the last day of final exams. Breaks which last five days or longer, including the preceding and subsequent weekends, are not counted. Thanksgiving and Spring Break are not counted. There is no tuition adjustment after 60% of the semester is completed. No tuition is charged to a student who is administratively withdrawn. See The HUB website for the complete tuition assessment schedule for the current semester.

Housing, Dining Plan & Fee Adjustments

Housing charges are adjusted daily, beginning on check-in day and ending on the last day of final exams for the semester. Holiday breaks are included. The Winter Break period is not included.

Dining plan charges are adjusted per the bi-weekly period. DineXtra and PlaidCa\$h are assessed based upon actual use.

There is no adjustment of the Port Authority Fee, the Technology Fee or Student Activity fee.

Financial Aid Adjustment

Federal and institutional financial aid is adjusted on the same basis as tuition. A student earns 100% of his or her federal or institutional financial aid when 60% of the semester is completed.

State grants and non-federal outside scholarships are adjusted based upon the withdrawal policy of the agency awarding the funds.

Contact

Questions concerning this policy or its intent should be directed to: The HUB, (412) 268-8186.

Student Accounts Receivable Collection Policy and Procedures

The Student Accounts Receivable Collection Policy and Procedures is currently under review, with the expectation that the policy will be vacated. In the interim, the current Student Financial Obligation Statement is the appropriate reference point. That statement is provided to all students through Student Information Online (SIO), and may be accessed at <http://www.cmu.edu/hub/billing/sfo/>. Questions about this statement may be directed to Brian Hill, Director of Student Accounts.

Financial Aid Policy Statement

University Academic Scholarship Renewals

Carnegie Mellon University awards academic scholarships as part of the freshman financial aid process. Each of these scholarships is renewable for four academic years of study (five for architecture) based upon the maintenance of a specific cumulative quality point average. The academic scholarship renewal criteria are included in the scholarship notification letter which is mailed to the student prior to the May 1 matriculation deadline.

Each scholarship recipient's cumulative quality point average is reviewed at the end of each academic year. If the student achieves the scholarship renewal criteria, then the scholarship is automatically renewed for the next academic year.

If the student does not meet the cumulative quality point average requirement for renewal, then s/he is given the opportunity to appeal. A merit scholarship appeal form and instructions are automatically sent to the student at the end of each academic year.

The student's completed appeal form is reviewed by members of the Enrollment Services staff. Input from the Associate Dean of the student's college is also considered. The student is notified, in writing, of the decision. The decision may be to renew the scholarship for the entire academic year, renew the scholarship for one academic term, or to reject the appeal. If the appeal is rejected, a written explanation is provided to the student.

Undergraduate Tuition Exchange Programs

Carnegie Mellon University assesses the standard tuition charge for the undergraduate tuition exchange programs.

Since Carnegie Mellon assesses the tuition charge, the student can be considered for all forms of institutional, state, and federal aid for which the student may have eligibility with the exception of any student employment program.

Undergraduate Study Abroad Programs

Carnegie Mellon University does not assess the tuition charge for any of the Study Abroad Programs.

Since Carnegie Mellon does not assess the tuition charge, the student is not considered for any institutional grants and scholarships. However, Carnegie Mellon will consider any student participating in an approved Study Abroad Program for all state and federal student aid programs for which the student may have eligibility with the exception of any student employment program.

The U.S. Department of Education and Carnegie Mellon University define an approved Study Abroad Program as one which is part of a contractual agreement between Carnegie Mellon and the host institution. Additionally, courses taken in the Study Abroad Program must be accepted for transfer to Carnegie Mellon by the Dean of the student's college.

Undergraduate Sponsored Study Abroad Programs

Carnegie Mellon assesses full tuition charges and all applicable fees to students participating in an undergraduate sponsored study abroad program.

Undergraduate International Students

Documentation Eligibility (U.S. Citizenship or Eligible Noncitizen)

You must be a U.S. Citizen or permanent resident alien to receive federal student aid. If you are a U.S. Citizen, but were not born in the United States, valid documentation includes a copy of your passport or naturalization certificate.

If you are a U.S. permanent resident alien or refugee, acceptable forms of verification include a photocopy of both sides of your I-551 or I-551C card.

Undergraduate international students are ineligible to receive any federal or state student financial aid. Additionally, Carnegie Mellon does not award any institutional financial aid funds to undergraduate international students.

Undergraduate Course Meeting Policy

No undergraduate classes, exams, academic, or artistic activities (including: extra help session, rehearsals, ROTC drill, make-up exams, etc.) are scheduled on weekdays between 4:30 p.m. and 6:30 p.m. Extra class time beyond those regularly scheduled must take place either before 4:30 p.m. or after 6:30 p.m.

Undergraduate Course Meeting Procedure

This policy is not intended to reduce the rigor or vigor of the academic or artistic programs, but to ensure that students have a period in which they are free to carry on co-curricular activities and athletics. Scheduling classes, exams, or other academic and artistic activities makes it very difficult for the students to meet these commitments. Since we are all concerned about the quality of life at the university, this time must be held for the students.

In planning the academic course schedule, Enrollment Services will review all courses to ensure that no academic or artistic courses be scheduled in this period. In addition, any requests to schedule additional or makeup course meetings, review and/or study sessions, teaching assistant office hours, or other course-related meetings, must take place either before 4:30 p.m. or after 6:30 p.m. This includes meetings in all university spaces, not just within Enrollment Services controlled classrooms.

As with any policy, there must be a means of making exceptions. Any academic or artistic activities which you feel must be scheduled between 4:30 p.m. and 6:30 p.m. must be cleared with the Vice President for Enrollment. These requests must be in writing either as a memo or through e-mail (we16@andrew.cmu.edu). All requests must include the course relationship, intent for the requested meeting, and the reason why the meeting cannot be held either before 4:30 p.m. or after 6:30 p.m.

Any further clarification of this policy can be addressed to the Vice President for Campus Affairs.

Statement of Assurance

Carnegie Mellon University does not discriminate in admission, employment, or administration of its programs or activities on the basis of race, color, national origin, sex, handicap or disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Furthermore, Carnegie Mellon University does not discriminate and is required not to discriminate in violation of federal, state, or local laws or executive orders.

Inquiries concerning the application of and compliance with this statement should be directed to the Vice President for Campus Affairs, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone 412-268-2056.

Obtain general information about Carnegie Mellon University by calling 412-268-2000.

Undergraduate Academic Regulations

Courses and Registration

Availability of Required Courses

In order to insure that students do not have to compete for access to their required courses, registration priority is given to students who are registering for courses in their primary major. Although the University encourages the exploration of other disciplines, access to courses outside a student's primary major (including those courses that fulfill requirements for an additional major, minor, etc.) is on a space-available basis and is not guaranteed.

Change in Schedule (Add/Drop)

Scheduling changes must be made within the period in the semester as established in the Official University Calendar. A student **cannot** drop a course by simply notifying the instructor(s) or by ceasing to attend class(es). A student dropping all of his/her courses (with the intent of leaving the university) must file an Application for Withdrawal or an Application for Leave of Absence (see the "Student Leave Policy" for more information).

Undergraduate students at Carnegie Mellon may drop a course by following the instructions for dropping a course in Student Information Online (SIO) on or before the appropriate deadline as published in the Official University Calendar. This applies to all courses with the exception of half-semester mini courses. When a course is dropped by these deadlines, the course is removed and does not appear on the academic record.

After the Add/Drop deadlines, or to drop below 36 units, students must see their advisor and submit a Course Withdrawal form.

The Late Add Form is used for adding a course or switching sections after the established add period and during the semester in which the course is offered. Students can check Student Information On-Line to see if the appropriate schedule changes have been made. Undergraduate students who add a course or switch a section after the established add period are required to obtain the permission of their home Dean's Office or the Head of their School. If adding a course would result in a schedule overload, the permission of the student's advisor is also required. Graduate students must have the permission of their department.

- If adding a course would result in a schedule overload, the signature of the student's advisor is also required if requested by Associate Dean/ Department Head.
- Graduate students must have the permission of their department.
- International students who wish to drop below full-time must consult the Office of International Education.

The deadline to add a mini course is the end of the first week of classes for that course. The deadline to drop a mini course is one week after the mid-point for that course.

Free Electives

A free elective is any Carnegie Mellon course that a student completes that is not being used to fulfill a college, school, major or minor requirement. A maximum of nine units of physical education and/or student-taught (StuCo) courses may be included in the tally of units required for graduation.

Overloads

The University is committed to insuring that each degree candidate has access to a normal course load before it permits other students to register for a greater than normal number of units. A normal course load has been established by each academic department. Students should check with their academic advisor, department head, or dean's office for the definition of a normal course load. Individual colleges may have overload policies that are more restrictive, therefore students should consult with their advisor when considering an overload. Students may register for an overload up to 12 units with the approval of their academic advisor if they have demonstrated their ability to successfully complete a normal course load. Successful completion of a normal course load is defined as having earned at least a 3.00 (3.50 for students in ECE) cumulative QPA through the preceding semester or at least a 3.00 (3.50 for students in ECE) semester QPA in the current semester (in which case all final grades must be recorded before the student can register for the overloaded class). Overloads greater than 12 units or other exceptions must have the approval of the student's Associate

Dean. Freshmen and transfer students are limited to a normal course load in their first semester of attendance.

Summer Classes

Per the Associate Deans' Council, undergraduate students are now limited to registering for 24 units in summer sessions without advisor approval.

If the advisor wishes to approve additional units, AFTER consulting with the student, advisors can increase the max units in S3 on the registration page.

Conduct of Classes

Students are expected to attend all scheduled classes unless the instructor explicitly informs the class that other ways of doing the work are acceptable. The action to be taken in regard to tardiness, absence from class or making up late work is the responsibility of the individual instructor; the instructor should consult with the department head and the student's dean if major action, such as dropping the student from the course, is being considered.

All classes will be held at their scheduled hour on days immediately before and after all holidays and recesses. Both faculty and students are expected to be present.

Members of athletic teams and other student organizations are permitted to be absent from classes to participate in authorized contests and presentations, either at home or out of town, provided the following conditions are met:

- All work missed must be made up to the satisfaction of the instructor(s) concerned;
- No trip shall involve an absence of more than two days, excluding days when classes are not scheduled;
- The total number of days of absence shall not exceed six per sport or per organization annually;
- Each student will obtain an absence authorization signed by the director or sponsor of the organization involved and by the Dean of Student Affairs. The student will present this authorization to the instructor. This is not an excuse for work missed.

Technology affords many students access to portable devices including cell phones, PDAs, and laptops. It is expected that students will respect the wishes of faculty with regard to the use of electronic devices within the academic environment.

Students who, because of religious beliefs, cannot attend class may arrange as individuals to be absent, provided the work missed is made up in a manner satisfactory to the instructor(s) of the class(es) missed.

No student shall leave a scheduled exercise because of the absence of the instructor until a reasonable time has passed. By tradition and as a matter of courtesy a student should wait 10 minutes before leaving.

Course Attendance and Enrollment

A student is responsible for the payment of charges incurred at the university by the stated payment deadline. The purpose of this policy statement is to detail the specific process and action steps to be used to resolve any outstanding student account balance.

Students will be held financially and academically accountable for course(s) which they attend or for which they are enrolled. Enrollment in a course which is not actively taken, or contrarily, the taking of a course for which enrollment has not been completed, will result in the assignment of a grade and responsibility for applicable tuition charges.

Students who fail to resolve their enrollment and balances will be prohibited from using university academic and administrative services. The services include, but are not limited to, computing facilities, library services, housing, dining, career center services, degree verification and the release of academic transcripts for the upcoming semester.

Undergraduate Course Meetings

Usually, no undergraduate classes, exams, academic, or artistic activities (including extra help sessions, rehearsals, ROTC drill, make-up exams, etc.) are scheduled on weekdays between 4:30 p.m. and 6:30 p.m. On occasion, some courses may be scheduled during these hours by Enrollment Services

when they also are offered at other times: students may elect to take such courses during the 4:30 to 6:30 p.m. period.

Grades

Grading Policies

Policy Statement

This policy offers details concerning university grading principles for students taking courses, whether those students are undergraduates, non-degree students or graduate students. This policy covers the specifics of Assigning and Changing Grades (including Final and Mid-Semester grades, In-completes and Conditional Failures), Grading Options (Audit and Pass/Fail), Drop/Withdrawals, Course Repeats, and defines the undergraduate and graduate Grading Standards.

Questions about grading for a specific course should be addressed to the instructor of the course in question. Graduate students with questions about Pass/Fail and Drop/Withdrawal should contact their individual programs. Appeals for an exception to any grading policy may be made by the dean's office of the student's home college.

1. Definitions

Certain terms are used in this document with specific meanings, as defined in this section.

Student means any full-time or part-time degree-seeking undergraduate or graduate student, or full-time or part-time non-degree student.

Non-degree student means a student who is not in a university degree program.

Faculty means members of the university's Faculty Organization as defined in the Faculty Handbook, plus instructors and special faculty appointments (even in the first year), and part-time faculty.

Instructor means a faculty member, teaching assistant, and/or lecturer who is the instructor of record, as recorded in the Student Information System (S3).

2. Policy Provisions

Assigning Grades

Final grades are awarded to each student, in each course scheduled, at the end of the semester, mini-semester or summer session. All students taking a course at Carnegie Mellon must be assigned grades.

The University Registrar's Office will query instructors who do not assign a grade to a student. Copies of the query regarding the lack of grade will be sent to the student, to the dean and to the department head. If the instructor does not assign a letter grade or an incomplete grade within one month of Enrollment Services query, the department head will be responsible for insuring that a grade is assigned.

Changing a Grade

A student who believes that an assigned grade is incorrect, may request that a final grade be changed. Final grades will be changed only in exceptional circumstances and only with the approval of the instructor and, for undergraduates, with the approval of the dean's office of the college/school offering the course; for graduate students, department approval is required. The intention of this policy is to insure that, under normal circumstances, all students in a class are treated equally and no student is unduly advantaged.

Mid-Semester Grades

Mid-semester grades provide valuable feedback to students as they assess their performance in courses. Furthermore, mid-semester grades and the QPA's they generate are used by Deans and advisors in identifying and dealing in a timely way with students in academic trouble. Therefore it is imperative that mid-semester grades accurately reflect student performance and are turned in on time.

Mid-semester grades are not permanent and are kept only until final grades are recorded. Because mid-semester grades are not permanent, changes of mid-semester grades as a rule will not be accepted.

Incomplete Grades

Carnegie Mellon students are expected to complete a course during the academic semester in which the course was taken. However, if the instructor agrees, a grade of I (incomplete) may be given when a student, for reasons beyond his or her control, has been unable to complete the work of a course, but the work completed to date is of passing quality and

the grade of incomplete provides no undue advantage to that student over other students.

In awarding an I grade, an instructor must specify the requirements for completing the work and designate a default letter grade where no further work is submitted. Students must complete the required course work no later than the end of the following academic semester, or sooner if required by prior agreement. The instructor must record the permanent grade by the last day of the examination period of that following semester, or Enrollment Services will administratively assign the default grade.

Conditional Failures

X grades are conditional failures. They are factored in the student grade point average as a failure in the semester they are awarded and can be replaced by nothing higher than a D. When awarding an X grade, the instructor specifies to the student the requirements necessary to achieve a grade of D. Requirements may be the completion of a prescribed course with a performance of C or better or may be specified work related to the course in which the student received the X. Students must complete the required course work no later than the end of the following academic semester, or sooner if required by prior agreement.

The instructor must record the permanent grade of D by the last day of the examination period of that following semester, or Enrollment Services will administratively assign the default grade of R.

Pass/No Pass Grades

Undergraduate students may elect to take a free-elective course pass/no-pass unless precluded by the course, the course's department or the student's home department/college. Policies for graduate students vary and students should be advised to check with their individual colleges/departments/programs for details.

A student must submit a Pass/No-Pass Form to the University Registrar's Office indicating the course they are electing as pass/no-pass before the end of the university's drop period. This decision is irreversible thereafter. No information regarding the student's decision will be passed on to the instructor. Instructors will submit letter grades, which will automatically be converted to pass/no-pass.

A through D work will receive credit for units passed and be recorded as P on the student's academic record; below D work will receive no credit and will be recorded as N on the student's academic record. No quality points will be assigned to P or N units; P or N units will not be factored into the student's QPA.

In exceptional circumstances, departments may ask to designate a course pass/no-pass or request that the course be evaluated only with letter grades. The College Council must approve designating a course as pass/no-pass only or as graded only. If such a decision will have an adverse effect on the requirements of any other college, Academic Council must review the decision. The decision to designate a course as graded or pass/no-pass must be made before the add period for the course and is irreversible thereafter.

Audit Grades

Auditing is presence in the classroom without receiving academic credit, a pass/fail or a letter grade. The extent of a student's participation must be arranged and approved by the course instructor. A student wishing to audit a course is required to register for the course, complete the Course Audit Approval Form, obtain permission of the course instructor and their advisor, and return the form to The HUB prior to the last day to add a course.

Any student enrolled full-time (36 units) may audit a course without additional charges. Part-time or non-degree students who choose to audit a course will be assessed tuition at the regular per-unit tuition rate.

Drop/Withdrawal Grades

Students at Carnegie Mellon may drop a course by accessing on-line registration on or before the drop deadline as published in the official university calendar. This applies to all courses with the exception of mini-semester courses. Policies for graduate students vary and students should be advised to check with their individual colleges/departments/programs for details. The deadline to drop a mini-semester course is the last day of the fourth week of the mini-semester course. When a course is dropped by these deadlines, the course is removed and does not appear on the academic record.

Undergraduate students who wish to withdraw from a course after the drop deadline must complete a Course Withdrawal form and **must** obtain their academic advisor's signature. The advisor will indicate whether they "recommend" or "not recommend" withdrawal from the course on the form, sign the petition, and assign the "W" (withdrawal) grade in S3. The "W" grade will appear on the academic record. Withdrawal grades do not apply to graduate students, except in CIT, HC, MCS, and TSB.

Undergraduates who are registered as full-time students as of the 10th day of classes are expected to remain full-time for the duration of the semester.

Full-time is defined as registered for a minimum of 36 units. Permission to drop below the 36-unit minimum can only be granted in extraordinary circumstances by the student's home Associate Dean. Undergraduates who are registered as part-time are also subject to the above deadlines to drop or withdraw from a course.

Course Repeats

When a course is repeated, all grades will be recorded on the official academic transcript and will be calculated in the student's QPA. This is the case regardless if the first grade for the course is a passing or failing grade, including Pass/Fail.

Undergraduate students who wish to repeat a course already passed must obtain approval from the student's Dean or Department Head. When a student takes a course s/he has already passed, only one set of units will count towards graduation requirements.

3. University Grading Standards

The undergraduate student Grading Standard is as follows:

Grade	Quality Points	Definition
A	4.0	Excellent
B	3.0	Good
C	2.0	Satisfactory
D	1.0	Passing
R	0.0	Failure
X	0.0	Conditional Failure
P	Non-Factorable	Passing
N	Non-Factorable	Not Passing
O	Non-Factorable	Audit
W	Non-Factorable	Withdrawal
I	Non-Factorable	Incomplete
AD	Non-Factorable	Credit granted for work completed at another institution or examination credit

This grading standard is for all students classified as seeking an undergraduate degree and special students taking undergraduate courses.

Any +/- grades received by undergraduate students when taking graduate-level courses will automatically convert to the corresponding letter grade as listed in the scale above.

The graduate student Grading Standard is as follows:

Grade	Quality Points	Definition
A+	4.33	(Not applicable to CIT or Dietrich College)
A	4.0	
A-	3.67	
B+	3.33	
B	3.00	
B-	2.67	
C+	2.33	
C	2.00	
C-	1.67	
D+	1.33	(Not applicable to Tepper School, Heinz College, or Dietrich College)
D	1.00	(Not applicable to Tepper School, Heinz College, or Dietrich College)
R	0.0	Failure
X	0.0	Conditional Failure
S	Non-Factorable	Satisfactory
P	Non-Factorable	Passing
N	Non-Factorable	Not Passing
O	Non-Factorable	Audit
W	Non-Factorable	Withdrawal
I	Non-Factorable	Incomplete
AD	Non-Factorable	Credit granted for work completed at another institution or examination credit

Grading standards are based upon a student's home academic program and is defined by their home college. The college's standards determine if certain grades are applicable and if undergraduate course are factored into their mid-semester and final semester quality point averages (QPA). Otherwise, the university policy is that only graduate courses (700 level and higher, unless a department specifies 600 level as graduate) are factored into the semester QPA.

Pass/Fail policies for graduate students vary and students should be advised to check with their individual college/department/program for details.

Minimum passing grades in graduate courses are determined by the department and college policy. Any course that a graduate student completes will be graded using this scale.* This includes undergraduate courses taken by graduate students, and non-degree students taking graduate courses.

Contact

Questions concerning this policy or its intent should be directed to the University Registrar's Office, (412) 268-7404.

Units and Quality Points

Carnegie Mellon has adopted the method of assigning a number of "units" for each course to represent the quantity of work required of students. For the average student, one unit represents one work-hour of time per week throughout the semester. The number of units in each course is fixed by the faculty member in consultation with the college offering the course. Three units are the equivalent of one traditional semester credit hour.

Hence, a 9 unit semester-long course should require 9 hours of student engagement, on average, including class time; if the instructor requires 3 hours of lecture and 1 hour of recitation, they can expect students to spend 5 hours outside of class engaging in class work. For mini courses that run for only seven weeks, the conversion from units to number of hours per week during the mini involves multiplying by 2. For example, a 6 unit mini course should on average involve 12 hours of student engagement; if the instructor requires 3 hours of lecture and 3 hours of lab, they can expect the students to spend 6 hours outside of class.

Final grades are given "Quality Point Values" as follows:

Grade	Meaning	Quality Point Value
A	Excellent	4
B	Good	3
C	(satisfactory)	2
D	Passing	1
R	Failure	0

Units earned for a course multiplied by the Quality Point Value of the grade given for that course equals the Quality Points for that course. For example, a 9-unit course assigned a "C" grade is awarded 18 quality points (9 units x 2 quality points = 18 quality points). Total Quality Points divided by Total Units Factorable equals the Quality Point Average.

For example, a student's record in one semester might be:

11 units x 4 quality points	=	44 quality points
10 units in Physics "R"		
10 units x 0 quality points	=	0 quality points
9 units in Chemistry "B"		
9 units x 3 quality points	=	27 quality points
9 units in History "C"		
9 units x 2 quality points	=	18 quality points
9 units in English "D"		
9 units x 1 quality point	=	9 quality points
Total Units = 48		
Total Quality Points = 98		
Quality Point Average (98 divided by 48) = 2.04		

"I" (incomplete), "P" (pass), and "W" (withdrawal) grades are not awarded quality points and are not considered as "factorable" units when calculating the QPA.

The same procedure is applied to all grades earned at the university to establish the Cumulative Quality Point Average.

Dean's List

Undergraduate students who meet specific academic requirements are added to their home college's Dean's List each semester. This is noted on the student's transcript for applicable semesters. Each college may have its own requirements for Dean's List qualification; these are described in the individual college sections of the Catalog.

Note: Only undergraduate *degree-seeking* students may earn a place on the Dean's List. Non-degree students are not eligible.

Transfer Credit Evaluation and Assignment Policy

The Policy on Grades for Transfer Courses, originally dated January 13, 1993, and approved by the Committee on Educational Programs and Student and Faculty Affairs states:

"Carnegie Mellon University offers students the opportunity to take courses for credit through a cross-registration program and through the receipt of transfer credit from other accredited institutions. The Carnegie Mellon University transcript will include information on such courses as follows:

Carnegie Mellon courses and courses taken through the university's cross-registration program will have grades recorded on the transcript and be factored into the QPA. All other courses will be recorded on this transcript indicating where the course was taken, but without grade. Such courses will not be taken into account for academic actions, honors or QPA calculations. (Note: Suspended students may take courses elsewhere; however, they may receive transfer credit only if their college's and department's policies allow this).

Definitions

A Carnegie Mellon course is one conducted under Carnegie Mellon University regulations regarding course content and grading and taught by faculty under the supervision of a Carnegie Mellon academic unit. Courses taught by Carnegie Mellon faculty on the Carnegie Mellon campus qualify. Courses that are part of the regular offerings of other universities do not qualify, unless faculty at the other universities receive appointments at Carnegie Mellon and handle Carnegie Mellon students under Carnegie Mellon academic regulations.

Courses offered for cross-registration are those taken under the PCHE (Pittsburgh Council on Higher Education) agreement during the regular academic year."

Only official and final college or university transcripts will be accepted for the awarding of transfer credit. Grade reports, letters and the like are not acceptable. It is the responsibility of the Office of Undergraduate Admission and the University Registrar's Office to verify official transcripts. Official transcripts for the awarding of transfer credit will reside in the student's permanent university academic folder in the University Registrar's Office.

It is the responsibility of each academic department to review and establish transfer course credit for their degree-seeking students.

Transfer Credit Evaluation Procedure

External Transfer Students

External applicants applying for transfer to Carnegie Mellon will arrange for submission of:

- official transcripts to the Office of Undergraduate Admission as part of the admission process.
- official, final transcripts to the Office of Undergraduate Admission once they are admitted and prior to their beginning coursework at Carnegie Mellon.

As part of the admission process, Admission will verify the official final transcripts, and then send them to the appropriate academic unit responsible for college/department acceptance decisions. Each unit will be responsible for student's review of transfer credit and the establishment of transfer course credit for each individual student.

Current Students

Current Carnegie Mellon students taking courses at other accredited institutions (colleges and universities), during either summer semesters or as part of exchange programs or other departmentally approved programs, or while on leave from Carnegie Mellon, must arrange for the submission of official final transcripts to the University Registrar's Office.

Upon receipt, Enrollment Services will verify these official transcripts and send a copy of the transcript to the appropriate academic unit responsible for that student's college/department transfer credit decisions. The official transcript will reside in the student's university academic folder in

Enrollment Services. Each unit will be responsible for its students' transfer credit review and the establishment of transfer course credit for each individual student. Should a unit receive the official transcript, it must be sent immediately to the University Registrar's Office.

Standard Course Equivalents for Advanced Placement/International Baccalaureate Units Policy

The university has standard units assigned to Advanced Placement (AP) and International Baccalaureate (IB) credits for all majors. Standard course equivalencies for each exam will be determined by "expert departments" in each college for each acceptable AP/IB score.

Under this procedure, students' AP or IB credit for a particular course will only go toward their degree requirements if allowed by the home department or college policies. Should a student decide to transfer to another major and/or academic unit within the university, AP/IB credits applicability to new degree requirements will depend upon the requirements of the new home department (or college). Students may only be granted credit for the Higher Level IB exams. This policy assumes no significant AP and/or IB exam changes. In the event of significant exam changes, students will be notified of any resulting policy changes no later than July 30 prior to their enrollment to take effect the fall of that year.

Rank in Class

Undergraduates at Carnegie Mellon pursue degrees in one or more of our ten schools or colleges. They may choose to pursue coursework, majors and minors within and between schools/colleges. In an institution where students' educational experiences are so varied, class rank is not a meaningful way to measure achievement.

Carnegie Mellon and Enrollment Services does not report nor record students' rank in class, rank in college and rank in department. For those graduate school and/or employment requests that request a students' rank, they will be completed with the statement "Carnegie Mellon does not report rank in class."

Official Transcripts and Verifications

Transcripts

The student's official transcript is to be considered the official record for all degree(s), major(s), minor(s), and honors. The official Carnegie Mellon transcript includes both the undergraduate and graduate record. All transcripts come in individually sealed envelopes, unless otherwise specified. Transcript requests are not processed if the student has an outstanding obligation, financial or otherwise. We cannot accept phone or e-mail requests. We will not fax a transcript under any circumstances.

Visit The HUB website, www.cmu.edu/hub, for complete information, including information on ordering official transcripts.

Verifications

Enrollment verifications are available only for currently enrolled Carnegie Mellon students and Carnegie Mellon Alumni.

An enrollment verification officially confirms information about you. Please note that we cannot fax your QPA or verifications that contain anything besides the following:

- Name
- Local address
- Local phone number
- E-mail address
- Class
- College
- Department
- Dates of attendance
- Date(s) of graduation
- Degree(s) awarded

The most common reasons for requesting a verification are:

- Student loan agencies and insurance companies wanting to know if a student is enrolled.

- Scholarship committees wanting to know if a student maintained a certain QPA.
- Potential employers wanting to know if a student graduated with a certain degree.

On-Line Verification Ordering

Currently enrolled Carnegie Mellon students may order enrollment verifications via Student Information On-Line (<https://s3.as.cmu.edu/sio>).

For additional information, visit The HUB website (<http://www.cmu.edu/hub>).

Full-Time Status

Undergraduates who are registered as full-time students as of the 10th day of classes are expected to remain full-time for the duration of the semester. Full-time is defined by a minimum of 36 units. Permission to drop below the 36 unit minimum must be granted by the student's Associate Dean. Undergraduates who are registered as part-time are also subject to the above deadlines to drop or withdraw from a course.

Students carrying a full-time course load as of the 10th regularly scheduled class day are not ordinarily permitted to drop below 36 units after that time. Exceptions must be authorized by the student's Associate Dean.

Status, Class Standing

Students should refer to the sections of the catalog pertaining to their college and/or department to determine the number of units required each academic year by their specific curriculum. Students must achieve passing grades in order to earn units; students do not earn units for incomplete or failed courses.

A freshman student becomes a sophomore after earning passing grades in three-fourths of the units required by his/her freshman curriculum.

A sophomore student becomes a junior after earning the number of units required by his/her curriculum for the freshman year plus three-fourths of the number of units for the sophomore year.

A junior student becomes a senior after earning the number of units required by his/her curriculum for the freshman and sophomore years plus three-fourths of the number of units for the junior year.

Classification of students is made only at the time of their first registration in any academic year and remains unchanged throughout the rest of that academic year.

Course Description Requests (for prior years)

Please note that University Archives does not have access to transcript and verification information. They maintain only the course description archives. If you call or e-mail this office, your request will not be processed. Please contact:

Archives/Art Inventory Specialist
Carnegie Mellon University Libraries
4909 Frew St.
Pittsburgh, PA 15213
(412)268-5021 (phone)
(412)268-7148 (fax)

Graduation & Diplomas

Degree Requirements

Students are responsible for checking to ensure that the degree requirements (as listed in the appropriate catalog at the time of their matriculation) have been met. They may also refer to the university's on-line academic audit website: <https://enr-apps.as.cmu.edu/audit/audit>. If the degree requirements have been modified by College Council action, the student is responsible for checking to ensure that the modified requirements have been met.

To be eligible to graduate, undergraduate students must complete all residence and course requirements for their program with a cumulative Quality Point Average of at least 2.0 for all courses taken. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on

all grades in all courses taken, including freshman year. Some programs may have additional QPA requirements in order to graduate. Students are encouraged to confirm all graduation requirements with their academic advisor.

No student may receive a diploma until all financial obligations to the university have been met.

Residency Requirement

A candidate for the bachelor's degree must complete at the university a minimum of four semesters of full-time study, or the equivalent of part-time study, comprising at least 180 units of coursework. Note that these are minimum residency requirements applicable to all university undergraduates. Some of the university's colleges and departments have developed more restrictive requirements in this area. Students should consult that section of the catalog in which their college or department's academic regulations are presented for the residency requirements applicable to them. Deviation from these policies requires action by the Dean of the student's home college.

Implications of Residency Requirements for transfer students seeking second undergraduate degree: Students who received degrees from other universities could have up to 2 years of credits earned elsewhere applied to their Carnegie Mellon degree requirements and would need to meet Carnegie Mellon's Residency Requirement and complete at the university a minimum of four semesters of full-time study, or the equivalent of part-time study, comprising at least 180 units of coursework. Deviation from these policies will require action by the Dean of the student's home college.

Diplomas

A Carnegie Mellon diploma is a student's certificate of accomplishment. The diploma is printed with the name the student approved within Graduation On-Line, along with the student's primary degree (i.e., Bachelor of Arts in Creative Writing). Minors are not listed on a diploma, although they do appear on an official transcript.

Diplomas are distributed to graduates during or immediately following the commencement ceremony. Certain circumstances will result in students receiving their diplomas at a later date, and such students will be informed of this well before the ceremony. If a student is unable to attend the ceremony, diplomas will be available for pick-up or mail-out in the weeks following commencement. Diplomas are not available prior to the stated date of graduation.

The diploma is 14x17 inches and is marked with a multi-colored and gold seal.

Graduation with University Honors

In recognition of exemplary academic achievement as undergraduates, some candidates for undergraduate degrees will be named to the University Honors List. Each of the undergraduate colleges will select students for honors on the basis of a cumulative grade point average (typically when cumulative QPA is greater than 3.5) and/or recommendation of the faculty.

Standard Degree Terminology

Carnegie Mellon University offers a wide variety of programs; the opportunities vary greatly between and among the colleges. For the purposes of clarification, this section defines:

- standard degree terminology;
- changes to the existing degree declaration process;
- the existing procedure for creating new degrees, majors and minors.

Degree

Examples: B.S. (Bachelor of Science); M.F.A. (Master of Fine Arts); Ph.D. (Doctor of Philosophy)

Major

Field studied in greatest depth by fulfilling a department-determined set of course requirements. The primary major is the field in which the degree is granted.

Example: Creative Writing; Physics; Marketing
Students may pursue an additional major(s) in a single degree program.

Minor

Field(s) studied for educational enrichment by fulfilling a department-determined set of course requirements. Graduate students may not pursue Minors. Minors are not listed on the diploma but appear, instead, on the

student's transcript. The type of degree sought is determined by the major (that of the home department), not the minor(s). Examples: Film Studies; History of Ideas

Option

(Now referred to variously as track, option, etc.)

A specific area of study associated with the major or additional major(s), which transforms the title of the major or additional major.

Examples: Civil Engineering (Biomedical Engineering Option) Physics (Computer Science Option)

Concentration

(Now referred to variously as track, option, etc.)

A specific area of study generally associated with a major or an additional major, which appears only on the transcript.

Home College

The college into which the student was originally admitted or into which the student formally transferred.

Home Department

The department into which the student was originally admitted or the department offering the major which the student has declared.

Concurrent College/Department

College/department other than the home college/department, granting the second of multiple degrees, or offering the additional major(s) of double or triple major, or minor.

Single Degree/Major

One diploma, stating the degree and the major field of study. Currently, the Statute of Limitations on earning an undergraduate degree is eight years.

Examples: B.A. in Psychology; M.S. in Industrial Administration

Requirements: Fulfillment of all requirements of the home college.

Declaration: At least by registration time (early November), first semester junior year.

Certification: Home college, home department

Major-Declaration Process

For undergraduates, depending on the student's college, the major is usually declared at the end of the freshman or sophomore year. Departments enter the appropriate majors upon declaration.

For graduates, the major is usually indicative of the department and is supplied by the department.

Joint Degree

Degree program offered between two or more colleges/departments or offered in conjunction with an outside University.

Examples: M.S. in Colloids, Polymers, and Surfaces (Chemistry and Chemical Engineering); B.H.A from College of Fine Arts and Humanities and Social Sciences.

Multiple Degrees

More than one degree granted by the university (whether simultaneous or sequential). One diploma for each degree. When awarded simultaneously, two degrees are referred to as dual degrees, three degrees as triple degrees. Multiple graduate degrees may be given in conjunction with (an) outside University(ies).

Examples of how such degrees appear on the respective diplomas:

- Bachelor of Fine Arts in the field of Art; Bachelor of Science in the field of History
- Bachelor of Science in the field of Physics; Bachelor of Science in the field of Computer Science

Requirements: Multiple bachelor's degrees

Declaration: Undergraduates: at least by registration time (early November), semester junior year

To receive multiple bachelor's degrees the student must:

- satisfy all requirements for each degree.
- complete an aggregate number of units that exceeds, by at least 90, the minimum unit requirement for the degree with the smallest such requirement (e.g., if the one of the degrees requires a minimum of 360 units and the other requires 380 units, a total of at least 450 units (90 plus 360, the smallest of the two) is required to obtain both degrees).

- comply, for each degree, with the statute of limitations regarding the time at which units are earned.
- while working towards more than one degree simultaneously, designate one of the departments (and if necessary colleges) as the home college/department.

Additional Major

One degree, stating the major in the home department first and the additional major second. The type of degree given (B.A., B.S.) is determined by the major of the home department.

For example, a student whose home department is Physics:

This degree is valid: B.S. in Physics with an additional major in History

This degree is not valid: B.S. in History with an additional major in Physics

The intent of a double major is an in-depth understanding of two major fields. Students may pursue a second major in a field where the primary degree is different from the degree associated with the additional major: e.g., B.S. in Economics with an additional major in History.

Requirements: If the double majors involve two different colleges OR the same college, the student must fulfill:

- all requirements (including core) for the first major degree as defined by the home college;
- all major requirements (including core prerequisites) for the additional major;
- any specific requirements for double majors imposed by the department(s)/college(s) involved.

Declaration: At least by registration time (early November), first semester junior year.

Certification: Home college, home department; concurrent college (if any), concurrent department (if any).

Additional Majors

One degree, stating the major of the home departments first, the second and the third major afterwards. The type of degree sought (B.A., B.S.) is determined by the major in the home department.

For example, a History student, this degree is valid: B.A. in History with additional majors in Professional Writing and in Hispanic Studies. This degree is not valid: B.A. in Professional Writing with additional majors in History and in Spanish.

Requirements: If the triple major involves two or three different colleges OR the same college, the student must fulfill all requirements listed for each additional major.

Declaration: At least by registration time (early November), first semester junior year.

Certification: department

Concurrent college (if any), concurrent department (if any)

Second concurrent college (if any), second concurrent department (if any)

Minor

One degree, stating the major first and the minor second (or third, if there is also (an) additional major(s) involved). The type of degree sought (B.A., B.S.) is determined by the major (that of the home department). Minors are not listed on the diploma, but appear on the transcript.

Examples: B.F.A. in Music Performance (Voice) with a minor in Theatre Arts; B.S. in Applied History with an additional major in Information Systems and a minor in Mathematics.

Requirements: The student would generally take 45 units pertaining to the minor, in addition to fulfilling all requirements for the major degree (as defined by the home college). The "minor" courses are negotiated between the student and the department certifying the minor.

Declaration: At least by registration time (early November), first semester junior year.

Certification: department

Options (Tracks, Specializations, Area Cores, etc.)

These concentrations will not be considered part of the student's degree title unless included are part of the major or (an) additional major(s) field title.

Additional Majors/Minors Declaration Process

For undergraduates, all variations on a student's sought degree and major field must be declared by the end of the first semester of the student's junior year. Having already declared a major, students should be well prepared by this time to choose additional majors and/or minors.

It is assumed that by these proposed deadlines, the student will have taken a majority of degree requirements and electives. The student can then, in conjunction with an advisor, review his/her course history and decide which options may or may not apply towards the desired degree and field(s).

A student who wishes to pursue additional majors and/or minors should consult with his/her advisor and receive a detailed curriculum for attaining the additional desired degree, major or minor. The student should then notify the college/department offering the additional program. Upon receipt of this notification, the college/department will update the Student Information System which will reflect this information to the Commencement System for graduation. This procedure ensures that when a student is expected to graduate, all degree/major information is immediately accessible, and certification of the degree is simplified.

Multiple Degrees Involving Graduate Degrees

Policies involving multiple graduate degrees or a graduate/undergraduate degree program or sequence are dictated by each college involved.

Examples: M.S. in Public Management and Policy and the degree of Juris Doctor (Heinz College/University of Pittsburgh School of Law).

Declaration: Undergraduates: at least by registration time (early November), first semester junior year.

Declaration: Graduates: upon admittance OR by the end of the semester preceding the expected graduation date.

Certification: Home college, home department and concurrent college (if any), concurrent department (if any).

Academic Actions

Each college may have its own regulations and procedures regarding academic actions, but in general, the following apply to all undergraduate students:

Student Suspension/Required Withdrawal Policy

Policy Statement

University Suspension is a forced, temporary leave from the university. There are three types of suspension for students that apply to both graduate and undergraduate students:

Academic Suspension is the result of poor academic performance or violation of academic regulations and is imposed by the student's college or academic department (see university and college academic policies).

Disciplinary Suspension is the result of serious personal misconduct and is imposed by the Office of Student Affairs (see The Word/Student Handbook).

Administrative Suspension is the result of failure to meet university financial obligations or failure to comply with federal, state or local health regulations and is imposed by Enrollment Services. (See Student Accounts Receivable Collection Policy and Procedures for financial obligations. Contact Student Health Services for information about health regulations.)

Suspended students may not:

- register for courses
- attend classes
- live in residence halls or Greek housing
- use campus facilities, including athletic facilities, library and computer clusters
- participate in student activities
- be members of student organizations
- have student jobs

(Note: students on academic suspension may have a summer campus job if they accepted the job before they were suspended.)

Employment

Although suspended students may not hold student jobs, students on academic suspension may, under certain circumstances, have a non-student

job with the university; students on disciplinary or administrative suspension may not.

To have a non-student job, students on academic suspension must receive approval from their associate dean (undergraduate students) or department head (graduate students) to ensure that the job will not violate their suspension terms. Students in violation of this will lose their degree student status, meaning they would have to reapply for admission to Carnegie Mellon through either Undergraduate Admission or the appropriate graduate department.

Transfer Credit

Suspended students may take courses elsewhere; however, they may receive transfer credit only if their college's and department's policies allow this.

Appeals

To appeal any action of this policy, the student may write to the following people:

Academic Suspension - associate dean (undergraduate students) or department head (graduate students);

Disciplinary Suspension - dean of student affairs;

Administrative Suspension - vice president for campus affairs, vice president for business and planning, and the dean of student affairs, in consultation with the student's associate dean.

Returning from Suspension

In order to return from a suspension, a student must have the following approval:

Academic Suspension - associate dean (undergraduate students) or department head (graduate students);

Disciplinary Suspension - dean of student affairs;

Administrative Suspension - vice president for campus affairs or his designate.

Contact

Questions concerning this policy or its intent should be directed to The HUB, x88186.

Procedure for the Appeal of Grades & Academic Actions

In the event a student believes an assigned grade or an imposed academic action is incorrect or not appropriate, the student may follow the processes outlined below to seek prompt and equitable resolution of the matter.

If a student believes a grade has been incorrectly assigned, the student should:

1. Present the case to the faculty member responsible for the course, providing all supporting data concerning the nature of the discrepancy.
2. If, after a decision is rendered, the student believes that his or her concerns have not been adequately resolved, the student may pursue a formal appeal with the department responsible for the course. To appeal to the department, a student must present a written statement detailing the grounds for the appeal with appropriate documentation to the head of the department responsible for the course. This appeal must be submitted within seven (7) days of receipt of the faculty member's decision. The department head will provide a written decision, including the basis for it, within thirty (30) days, or as soon thereafter as practical.
3. If the student is not satisfied with the department head's resolution, the student may pursue the appeal at the college level. To appeal at the college level, the student must present copies of all documents originally sent to the faculty member and department head, along with a formal letter of appeal, to the dean of the college responsible for the course. This appeal must be submitted within seven (7) days of receipt of the department head's decision. The dean, or the dean's designate, will review the appeal and will render a written decision, including the basis for it, within thirty (30) days, or as soon thereafter as practical.

If a student believes an academic action is inconsistent with the policies of the college or merits additional review, a student should:

1. Submit a formal written appeal, as specified in the initial academic action, to the associate dean of the college responsible for the decision, with a copy to the dean, requesting review of the action including

all relevant materials to substantiate their case and support their concerns.

- The dean of the college, or the dean's designate, will review the appeal and issue a decision and the basis for it within thirty (30) days.

If, after carrying out the steps of either process described above, the student believes that the matter has not been adequately resolved, or if no decision has been rendered by the appropriate date, the student may appeal at the university level. To appeal at the university level, the student must present copies of all previously submitted documents and a formal letter of appeal to the provost. The provost or another designated university officer will respond in writing with a final resolution, including the basis for it, within thirty (30) days, or as soon thereafter as practical.

Other Academic Regulations

Level of English Fluency Needed for Non-Native English Speakers

To be successful at Carnegie Mellon University, students who are nonnative speakers of English need to begin their undergraduate work with a strong foundation in academic English and a high level of proficiency with speaking, reading and writing in English. The importance of English language abilities cannot be overstated since there are no basic ESL language courses at Carnegie Mellon. All students will have sufficient English language proficiency to be able to participate fully in the academic work and to interact in daily life outside of the classroom.

Students' English fluency will enable them to handle the demands of academic work, including the ability to comprehend, process, and master complex material presented in English, both in written and spoken form. Students will possess the fluency to communicate their ideas and questions to faculty, classmates, and others, in a classroom environment that is often highly participatory. For example, many classes require group discussion, team projects, oral presentations, and/or independent research. In addition to fluent English skills, studying in a new culture requires openness and flexibility to adapt to a new, and often very different, academic system.

To assess the language of nonnative speaking applicants, a minimum TOEFL score of 600 (paper based, PBT), or 100 (internet based, iBT) has been established as the standard for admission. This minimum score indicates that an applicant has the fundamental building blocks of language needed for academic tasks and for continued language development. Since neither the PBT or CBT versions of TOEFL assess speaking, students who took these tests should additionally seek feedback on their speaking skills and work to improve conversational skills before beginning academic work.

Exchange Students

Each term, Carnegie Mellon welcomes exchange students from partner institutions around the world. Exchange students enrich the learning experience at Carnegie Mellon and are expected to be full participants in the curricular and metacurricular life. Therefore, their admission should adhere to the English language guidelines described above. Exchange students submit standardized English language testing scores (such as the TOEFL) as part of the Exchange application process, and present the same high level of English language abilities as degree-seeking students. With exchange students, high-level English abilities are particularly critical since academic, personal and extracurricular experiences must be maximized in a short period of time sometimes only four months in duration.

Withdrawal of a Degree

The university reserves the right to withdraw a degree even though it has been granted should there be discovery that the work upon which it was based or the academic records in support of it had been falsified. In such a case the degree will be withdrawn promptly upon discovery of the falsification.

Information for Graduates

Graduating students may wear one stole ONLY with their academic regalia. Students are certainly permitted to receive/purchase more than one stole if they are a member of multiple organizations that issue stoles and may chose to wear a particular stole to the main commencement ceremony and another to their diploma ceremony.

Graduating seniors that are a member of a club/organization that issues a pin to designate affiliation are permitted to wear more than one pin with the academic regalia in addition to one stole.

Retention of Student Work

The university reserves the right in all colleges to retain indefinitely any student work the faculty may select. All work not retained by the university must be claimed at the time specified on the bulletin boards (or other forms of communication) of the department concerned; otherwise, the work will be destroyed.

Statute of Limitations

All units required for an undergraduate degree, whether earned in residence, transferred from another institution or granted via advanced placement, must have been earned within eight years of the date on which the degree is granted. This statutory period can be extended by the Dean of the student's college under the following conditions:

- the courses taken prior to the statutory period still represent a reasonable part of the student's total academic program;
- the prior courses provide adequate preparation for courses which must still be taken to fulfill the degree requirements;
- there is a legitimate reason(s) for the student not completing the academic program within the statutory period.

A request for a waiver of the statute of limitations must be submitted to the Dean of the student's college. The request for a waiver should address all of the above conditions for an extension. For cases in which a waiver is granted, the waiver covers specific courses and is intended for a specific period during which the program must be completed.

Transitional Students

Transitional student status has been instituted by the university to assist students who have changed their minds about their original field of study or who have been judged unlikely to make satisfactory progress in their chosen field. Becoming a Transitional Student gives a student an opportunity to maintain a relationship with the home college while re-orienting academic plans and goals. It also gives a student time to explore his/her options and/or enhance admissibility to another college in the university, or to another institution. Ordinarily, a student will be permitted to register as a Transitional student for no more than one semester. Although, in exceptional circumstances, a student may be allowed to extend the status beyond one semester. A student must obtain the permission of his/her home college Associate Dean to initiate this option.

Transitional student status may be available to students upon the advice of their advisor, or upon their own request. Interested students must make an appointment with the Associate Dean of their home college to discuss this option.

Note: Students at Carnegie Mellon in good academic standing may transfer from one program to another as long as they meet curricular or artistic requirements and as long as there is space in the program into which they wish to transfer.

Process for Creation of New Degrees, Majors, or Minors

Departments proposing new degrees, majors, additional majors, and/or minors must complete a New Degree/Major/Minor Request Form. This should include any and all notations to the university diploma and/or transcript (new degrees, majors, minors, options). Departments proposing to offer a new degree, major, additional major and/or minor must follow university policies for approval as follows:

- Document the Program by completing the New Degree/Major/Minor Request Form. Departments proposing new degrees and majors must complete this form and attach course descriptions, curriculum proposal, list of present faculty who will support the Program, and verify the availability of other units' courses. This documentation must indicate the starting semester for the Program, and in the case of new majors, also indicate if it is available only as a major/additional major/minor, or in combination.
- Receive Department approval.
- Receive Dean and College Council approval.
- Submit all Program documentation complete with College Council approval to the Vice Provost for Education. New majors or degrees will not be processed without the approval of the Provost's Office.

- Submit all Program documentation complete with College Council approval to the Vice Provost for Education. New majors or degrees will not be processed without the approval of the Provost's Office.
- The Provost's Office will approve or deny, and inform the sponsoring Department and Enrollment Services.
- The Department may then publicize and offer the program for student enrollment.

University Services

Academic Advising

Carnegie Mellon recognizes the vital role of academic advising in undergraduate education. The university assigns an academic advisor to each student, and makes certain that all advisors have clear, timely, and accurate information concerning programs, policies, procedures, and resources. In addition to having assigned academic advisors, students often develop relationships with faculty and staff members who serve as academic mentors.

Institutional Statement on Advising

Academic advising is integral to the educational mission of Carnegie Mellon. Advising is an intentional process, grounded in teaching and learning, and provides each student with guidance for developing and achieving meaningful educational, professional, and personal goals. Successful advising at Carnegie Mellon depends upon a shared understanding of, and commitment to, the advising process, by students, advisors, and the university. Academic advisors engage students in learning, promote students' academic success, and foster students' personal, ethical, and intellectual growth, all of which will carry into their roles as citizens and lifelong learners.

The Student's Role in Academic Advising

Seeking advice is an important part of how students begin to make decisions about their academic and professional futures. Each major and department has an advising system which may be different from one another. It is important that students find out early from their first year advisor how the advising system for all their four years at Carnegie Mellon works.

Students are responsible for: understanding the importance of their relationships with advisors; seeking out advisors, contacts, and information on a regular basis; knowing the requirements of their individual degree programs; and taking final responsibility for making their own decisions based on the best information and advice available. The Carnegie Mellon Advising Resource Center (CMARC) is an additional place for students to obtain information and general advice.

The Advisor's Role

To achieve the goals of academic advising at Carnegie Mellon, advisors, along with their advising programs, are responsible for: being knowledgeable of, and communicating, the requirements of the academic programs in which they advise; monitoring students' progress towards degree completion; being available to meet with students on a regular basis; assisting students in finding the appropriate institutional and community resources; involving students in the academic and career planning process and the exploration of options and resources; and engaging in developmental activities to stay informed of issues that impact student success.

Assistance for Individuals with Disabilities

Equal Opportunity Services

Whitfield Hall, 143 N. Craig Street, Pittsburgh PA 15213

<http://www.cmu.edu/hr/eos/index.html>

Everett Tademy, Director 412-268-2012, et19@andrew.cmu.edu

Larry Powell, EOS Manager 412-268-2013, lpowell@andrew.cmu.edu

Courtney Bryant, EOS Administrative Coordinator 412-268-2012, cbryant@andrew.cmu.edu

Qualified individuals with disabilities are entitled to reasonable accommodations under the Americans with Disabilities Act (ADA regulations). Accommodations are determined on a case-by-case basis. Equal Opportunity Services provide links between individuals with disabilities and the campus community. Information released will provide documentation of a disability for faculty, staff, students and prospective students of Carnegie Mellon University. All information will be considered confidential and only released to appropriate personnel on a need to know basis. To access services, individuals must initiate a request in writing for specific services/accommodations (books on tape, enlargements, interpreters, etc.). Accommodations prescribed only apply to Carnegie Mellon University and may not be valid elsewhere. The individual takes full responsibility for ongoing assistance.

In order to receive services/accommodations verification of a disability according to Carnegie Mellon guidelines is required.

To establish that an individual is covered under the ADA, the documentation must indicate that the disability substantially limits some major life activity, including learning. The documentation requirements are provided in the interest of assuring that a disability demonstrates an impact on a major life activity, is appropriate to verify eligibility, assures the implementation of appropriate accommodations, and supports the request for accommodations, academic adjustments, and/or auxiliary aids.

For more information on disability resources and documentation guidelines please contact Larry Powell, EOS Manager (412) 268-2013 or lpowell@andrew.cmu.edu or visit our website (<http://hr.web.cmu.edu/eos.html>).

Carnegie Mellon Resource Advising Center (CMARC)

Ty Walton, Director
Cyert Hall A64, 412-268-2150

The Carnegie Mellon Advising Resource Center (CMARC) is an advising and information center that assists students and connects them to appropriate communities, services and opportunities by providing academic planning and one-on-one counsel. Founded as the Carnegie Mellon Action Project (CMAP), CMARC has an additional commitment to support underrepresented ethnic minority students in a setting where students' differences and talents are guided, appreciated, and reinforced.

Academic Advising

CMARC, working in cooperation with faculty and departmental advisors, strives to promote academic success. The professional program advisors serve as an additional resource when it is necessary to consult with more than one person or to obtain another perspective. Their primary objective is to assist students in developing and achieving meaningful educational plans that are compatible with their life goals. CMARC advisors can help students:

- Establish short and long term academic goals.
- Investigate alternative majors in other colleges.
- Obtain referrals to organizations such as Career Services, Academic Development, etc.
- Explore career and graduate school options.

Computing Services

Steve Huth, Vice Provost Computing Services
Cyert Hall 281, 412-268-1075

<http://www.cmu.edu/computing/>

Computing on Campus

Computing Services maintains and supports computing resources for the campus community, including the campus wired and wireless networks, public printing, computer labs (clusters), email and software licensing.

To get started with computing at Carnegie Mellon, visit our Services for Students (<http://www.cmu.edu/computing/students>) page. Here you will find steps for connecting your computer or mobile/gaming devices to the network; accessing software; managing your Andrew account, password or email; using public printing and computer facilities.

If you need help with computing on campus, please contact the Computing Services Help Center at 412-268-HELP (4357) or advisor@andrew.cmu.edu.

Division of Student Affairs

Gina Casalegno, Dean of Student Affairs
Warner Hall 301

As much of undergraduate education focuses on preparation for professional careers, the university is strongly convinced that the total development of the student is critical to preparation for professional practice. A great deal of time and effort by the Division of Student Affairs, faculty and the university staff focuses on providing students with the opportunities to expand experiences outside the classroom, to encounter new intellectual

and social experiences, to undertake projects for personal growth, and to prepare for life.

Our vision and mission for the student experience is founded upon the intellectual, occupational, emotional, spiritual, physical, and cultural growth and nurturing of students. The Division of Student Affairs, and our partners throughout the university, are here to support you in reaching your highest potential in the areas of artistic and intellectual curiosity, personal well being, professional competency, leadership development, and engagement in and contribution to the larger community.

Staff members throughout the division are here to support and foster your intellectual and personal growth and help you explore and experience the different aspects of college life. We care about you, your studies, your social growth, your well-being and your future and want to help you enjoy a great Carnegie Mellon experience. Offices within the Division of Student Affairs include:

- Office of the Dean of Student Affairs
- Career Center
- Counseling and Psychological Services
- Health Services
- Office of International Education
- Office of Orientation and First Year Programs
- Office of Student Activities
- Student Development Office
- Student Life Office

Office of the Dean of Student Affairs

Gina Casalegno, Dean of Student Affairs
Warner Hall 301, 412-268-2075,
<http://www.cmu.edu/student-affairs/dean/>

The Office of the Dean provides central guidance and direction of student services at Carnegie Mellon. The dean is responsible for leading the Division of Student Affairs in providing students with quality services, programs, and experiences that support and complement the academic mission of the university.

While students are encouraged to seek out any member of the division for assistance, you may also meet with the dean of student affairs directly by calling 412-268-2075 and scheduling an appointment at your convenience.

Career and Professional Development Center

Kevin Monahan, Associate Dean for Career and Professional Development
University Center Lower Level, 412-268-2064
<http://www.cmu.edu/career>

Career exploration and planning

Whether you are interested in exploring post graduation options, or are clear on the direction you plan to pursue, the Career and Professional Development Center offers a complete range of resources. Students wishing to explore how majors and minors relate to career choice, as well as gain information about particular fields, will work with a career consultant to examine their skills, interests, and values and how they relate to various career fields. Career consultants also coach students in writing resumes and cover letters, networking, locating internship and job opportunities, preparing for interviews, and pursuing graduate school opportunities. Career consultants are assigned to each college and provide individualized support, general career programming, and college-specific workshops. In addition to the workshops presented by the Career and Professional Development Center staff, consultants coordinate an annual professional development series presented by prominent alumni and recruiters in various industries and fields. Finally, the Center's library and web page provide extensive resources on job search strategies, internships, summer opportunities and other career-related interests.

Job search

Several thousand summer internships and professional full-time job opportunities are made available to Carnegie Mellon students through TartanTRAK, our on-line job listing resource. Students can access TartanTRAK through the Center's homepage. TartanTRAK also provides information on the hundreds of employers that visit our campus each year. These organizations interview students for internships and professional employment as well as hold informational sessions in the evenings that are open to the entire campus. Average starting salaries offered to Carnegie Mellon graduates, in most fields, consistently rank above the national norms.

Student employment/Campus jobs

The Student Employment program promotes experiential learning and professional development. All campus job postings include learning objectives that help employers and students recognize and understand the professional and personal opportunities for growth presented by each position. The Student Employment website includes an on-line training and orientation program on topics ranging from business etiquette to the essentials of getting paid on time.

Student employment opportunities are posted on-line through TartanTRAK and include federal, state, and community service work-study jobs as well as non-work-study jobs. While having a work-study award does not guarantee a job, searching for and applying to opportunities are easily navigated through TartanTrak.

Counseling and Psychological Services

Morewood Gardens E-Tower, 412-268-2922,
<http://www.studentaffairs.cmu.edu/counseling>

Counseling and Psychological Services (CAPS) at Carnegie Mellon offers students the opportunity to talk about personal or academic concerns in a safe, confidential setting. Students come to CAPS for many reasons, including but not limited to problems with family, friends, or school; concerns about the future; and feelings of stress, low self-esteem, anxiety, depression, or loneliness.

We're here to talk with students about issues that are significant for them. We also offer consultation to staff, faculty, and parents who have concerns about a student's well-being. Any discussion regarding a client of the center necessitates a written consent by the student permitting us to release information, including whether the student has been seen at CAPS.

Counseling Center services are provided at no cost. There are, however, limits on the number of sessions that we are able to provide. Follow-up psychiatric services and off-campus referrals for longer term therapy are at the client's expense. The Counseling and Psychological Services office is open weekdays, and there is a professional on call for emergencies during evenings and on weekends.

Health Services

Anita Barkin, Director
Morewood Gardens E-Tower, 412-268-2157
<http://www.cmu.edu/health-services/index.html>

Student Health Services is staffed by physicians, advanced practice clinicians and registered nurses who provide general medical care, allergy injections, first aid, gynecological care and contraception as well as on-site pharmaceuticals. Examinations by Health Services staff for illness/injury are free of charge; however, fees for prescription medications, laboratory tests, diagnostic procedures and referral to the emergency room or specialists are the student's responsibility. Health Services also has a registered dietician and health educator on staff to assist students in addressing nutrition, drug and alcohol and other healthy lifestyle issues.

Patients are seen by appointment. Walk-in urgent care is provided. Appointments can be made by calling the office. If you have a medical problem or accident that requires immediate attention at night or on the weekend, you should contact University Police at 412-268-2323 for transportation to the emergency room. If you have an urgent problem and would like to speak with the physician on-call, you can do so by calling the Health Services number.

Health Insurance

In addition to providing direct health care, Health Services administers the Student Health Insurance Program. The Student Health insurance plan offers a high level of coverage in a wide network of health care providers and hospitals. It also covers most of the fees for care at Student Health Services. All full-time students are required to carry health insurance and will be assessed a charge for the individual basic mandatory plan offered through the university student health insurance program. The charge will appear on the invoice of the first semester of attendance in the academic cycle. The student is required to take one of the following three actions: (1) enroll in the basic plan as charged; (2) upgrade the benefit plan by enrolling in the enhanced student health insurance options during the open enrollment period; (3) apply for a waiver from the mandatory plan. Questions can be addressed to shinsure@andrew.cmu.edu.

Office of International Education

Linda Gentile, Director
Warner Hall, Third Floor, 412-268-5231
<http://www.cmu.edu/oie>

The Office of International Education (OIE) is committed to supporting, promoting, and celebrating individuals in an intercultural environment. We advocate for and facilitate international and cross cultural experiences, perspectives, and initiatives. OIE is the primary contact for study abroad programs and non-immigrant matters for all students and scholars (foreign professors and researchers) who are not United States citizens or permanent residents. OIE encourages both U.S. and international students to participate in international programs and events on campus, and we also welcome volunteers to participate and assist with programs sponsored by the office.

Foreign Students and Scholars

Carnegie Mellon hosts 2800 international students and 600 international scholars who come from more than 90 countries. International students make up 47% of the full-time graduate student body and 11% of our full-time undergraduates. OIE is the liaison to the university for all non-immigrant students and scholars. The foreign student and scholar advisors provide many services including: advising on immigration, academic, social and acculturation issues; presenting programs of interest such as international career workshops, tax workshops, and cross-cultural and immigration workshops; supporting international and cultural student groups such as the International Student Union and the International Spouses and Partners Organization; maintaining a foreign student resource library that includes information on cultural adjustment, international education and statistics on foreign students in the United States; posting pertinent information to students through email and our website, and conducting orientation programs.

Study Abroad

Carnegie Mellon students in every major can spend a summer, semester, or year abroad. Over 400 students go to all corners of the globe each year and receive credit for pre-approved study abroad. There is a wide range of funding options. The study abroad office assists students in all stages of the process of going abroad. The advisors promote study abroad, advise students, work with the academic departments and conduct information sessions, pre-departure orientations and welcome back workshops. For more detailed information about Carnegie Mellon's study abroad program, see the Undergraduate Options section of this catalog.

Office of Orientation and First Year Programs

Anne R. Witchner, Assistant Dean of Student Affairs
Morewood Gardens 1B8, 412-268-4887
<http://www.studentaffairs.cmu.edu/first-year>

The Office of Orientation and First Year Programs is responsible for providing vision and leadership for a comprehensive approach to new student orientation and transition programs. The office provides programs, opportunities and services to help students and family members successfully transition to the Carnegie Mellon community.

The office is responsible for program development, marketing and implementation of orientation and transition programs. Areas of concentration include: new student orientation, Family Weekend and special event planning.

Office of Student Activities

Elizabeth Vaughan, Director
University Center 103, 412-268-8704
<http://www.studentaffairs.cmu.edu/StudentActivities/>

The Office of Student Activities complements students' academic experiences by providing services and resources that engage students in creating campus culture through social, cultural, intellectual, spiritual, athletic, recreational, artistic, political, and service opportunities. Our staff is committed to delivering quality advising, resource materials, leadership development opportunities, and administrative support services to impact students' growth and development and enhance the success of each student organization.

Our office partners with students to create a vibrant culture of student life on the Carnegie Mellon campus. Our community is home to nearly 250 recognized student organizations that are supported by the Student Activities staff team. In addition to serving as individual advisors to many

organizations and providing resources, support, and ad hoc advising to all student organizations, our office also coordinates a slate of opportunities to help Carnegie Mellon students get involved in campus life.

To learn more about getting involved on campus, please visit our website where you can find information about recognized student organizations and about upcoming events on campus. If you are interested in forming a new organization, visit our office to learn more about how to get started. We look forward to helping you make your mark on the campus experience at Carnegie Mellon.

Student Life Office

John Hannon, Associate Dean of Student Affairs
Morewood Gardens A-Tower, 412-268-2142
<http://www.studentaffairs.cmu.edu/student-life/>

The Student Life Office provides opportunities that emphasize community engagement, leadership and social responsibility while actively supporting the personal and professional development of students. To this end, we coordinate residence life for first-year, upperclass and Greek students through our house model. Our professional staff, called Housefellows, advance a broad-based vision for student development by utilizing the residential house community as a focal point for the student experience on campus. The Housefellow's role involves serving as students' primary metacurricular advocate at the university while enhancing their social, academic, intellectual, artistic and personal development. Students lead the development and implementation of a vibrant, engaging experience in these houses through their work as Resident Assistants, Community Advisors or house council members, all of whom are advised by the Housefellow.

Additionally, the Student Life Office coordinates a number of developmental programs, initiatives and services for the broader campus community. We coordinate educational initiatives and accountability processes related to community standards; provide resources and facilitate programs related to gender and gay/lesbian/bisexual identity including GenderTalk and OUTSpoken, the MOSAIC conference, SafeZone training and Pride Month events; advise student safety initiatives such as Sexual Assault Advisors, 1 in 4, and Safewalk; advise and support the twenty-four social, Greek-letter organizations and associated governing bodies that comprise the fraternity and sorority community; offer leadership programs such as the First-Year Leader Retreat and Emerging Leaders; coordinate spirituality and meaning-making programs such as the Big Questions series; and advise the Student Dormitory Council.

Housing and Dining Services

Morewood E-Tower, 412-268-2139
www.cmu.edu/housing-dining/

Housing and Dining Services provides a variety of accommodations for Carnegie Mellon students. Living arrangements include traditional single-gender residence halls, coeducational residence halls, suites, apartments, houses and Greek living areas. All first year students, 17 years of age or older, are required to reside in University housing. The Dean of Student Affairs must approve first-year students who wish to be exempt from this requirement and would like to commute from home. Students who will not be 17 before the start of their first semester are asked to contact the Dean of Student Affairs. Transfer student housing is subject to availability and therefore, transfer students are also asked to contact Housing and Dining Services.

University housing is available on campus and in our Oakland Community Apartments. All on-campus residential areas are located in close proximity to academic buildings. The Oakland Community Apartments are located very near the campus and are an approximate 5-10 minute walk to campus. The university's shuttle bus services these areas on a regularly scheduled basis.

Furnishings and Amenities

Housing and Dining Services provides each resident with a bed, a desk and chair, a bookshelf, a dresser and a closet or wardrobe. Each room is also equipped with window coverings and cable TV, and all of our buildings have Ethernet or broadband service for fast data connectivity. Items such as pillows, linens, area rugs, cellular telephones (if desired), etc., are the student's responsibility. Oakland Community apartments have a broadband service modem with one outlet per apartment. Residents are responsible for any routers or switches needed to connect multiple computers to the modem.

Room Rates

Room rates include utilities, maintenance, a cable TV jack and Ethernet/broadband connection in each room, apartment, or house. Students pay separately for room and public area damages. Long distance phone access can be obtained by use of personal cell phones or calling cards purchased by the student and used at the courtesy phones.

Room Types

Residence hall rooms, apartments and houses are available through Housing and Dining Services and are priced according to these broad categories:

Residence hall rooms

- Grouped and priced by occupancy (# of students per room by design) and a classification (standard, prime, suite)
- Singles, doubles, triples, and quads are available
- No in-room cooking facilities
- Classification is primarily based on bathroom privacy, although other criteria may also be involved
- Standard rooms share a large, central bathroom facility
- Prime rooms generally share a private or semi-private bathroom with no more than five students
- Suite-style rooms share a semi-private bathroom, as well as a common living area

Apartments

- Efficiency, one-bedroom and two-bedroom apartments are available
- Grouped and priced by occupancy, location, and number of bedrooms
- In-room cooking facilities

Houses

- Grouped and priced by occupancy and location
- Includes bedrooms, a kitchen, a dining room, a living room, private bath and laundry facilities

Housing Reservations

Returning Student Room Selection

Each spring returning resident students will have an opportunity to reserve spaces in university housing through the Room Selection process that takes place in February and March. Returning students most often select apartments and residence hall rooms that offer more flexibility and privacy, features typically created by a kitchen and/or semi-private bathroom facilities.

First-Year Student Room Assignments

Most first-year students are assigned to traditional residence hall rooms where each floor shares a community bathroom. Because these traditional residence hall rooms (standard rooms) support the development of strong community, they provide excellent opportunities for first-year students to develop many friendships on their floor and throughout the building. While every effort is made for first-year students to share a room with other first-year students, a small number of first-year students will sometimes share a room with a returning student. If two first-year students request each other as roommates, their request will usually be honored as long as both applications are received before the May 31 deadline. Room assignments for first-year students are made in the order in which their original university deposits were processed by the Office of Admission. The Office of Admission provides Housing and Dining Services with the information concerning the date on which each incoming student deposit was processed.

Building and Room Preferences

We give our best effort in fulfilling each student's individual housing preferences, but it is often difficult to accommodate everyone's top choice due to the high demand for housing at Carnegie Mellon. The cost of attendance used in the calculation of a student's eligibility for financial aid includes a housing allowance that is based on a standard double room rate. Students are still responsible for the full cost of their room rate even if it is higher than the standard double rate.

Roommate Matching Procedures

A number of factors are taken into account when we make roommate assignments: a preference for a special residential program, specific hall or room type, smoking status, and college and major. Also factored into the equation is personal information about how you intend to utilize your room (social or study purposes), how clean you intend to maintain your room and

whether you consider yourself to be a "night" person or a "morning" person. Housing and Dining Services does not, and will not, discriminate in any way in regards to roommate matching. It is important for students to be honest when filling out the housing application as it will eliminate the potential for roommate conflicts.

Housing License Agreement

The Housing License Agreement is a binding document that states the terms and conditions of occupancy by which the student and the university intend to be legally bound including the dates of residence. The agreement is for two full terms, beginning with the fall semester. Housing and Dining Services advises students, parents and guardians to read the agreement thoroughly (a copy is available on our website, www.cmu.edu/housing/). The submission of the Housing License Agreement is an on-line process for both first year and upperclass students. The Housing License Agreement is signed by electronic signature and authenticated by Andrew ID through the WebISO process.

Important Information About Temporary Housing

Because housing is in high demand at Carnegie Mellon, occupancy pressures may dictate that a limited number of first-year students spend anywhere from a few days to a few weeks in temporary housing. Once it is time to relocate to a permanent assignment, Housing and Dining Services will orchestrate and assist in the move.

Housing Charges

The housing room charge is billed in three separate amounts. After charging and crediting the housing reservation fee, the University bills students for the balance of their academic year housing charges in two separate amounts, one each semester.

Cancellations

Only under very limited circumstances can Housing License Agreements be cancelled. These reasons include marriage, verified departure from the university, study abroad, or moves to Greek housing as defined by Greek leases and approved by Housing and Dining Services staff. The only contract cancellation requests that will be considered, other than those mentioned, are those based on verifiable medical or psychological hardship. Students interested in pursuing a contract cancellation based on one of these hardships may obtain the appropriate form at the Housing and Dining Services office.

Refunds

During the academic year, if a housing room payment should become refundable, the refund shall be recorded as a credit to the student's account with the University. Refund amounts are calculated on a pro-rated basis for the days remaining in the contractual term after the student completes the entire withdrawal procedure, which includes completion of the Request for Cancellation form and returning the room key to the Office of Housing and Dining Services.

Other Living Arrangements

Students moving into a fraternity or sorority house or leaving university housing (except to participate in an academic program away from the Pittsburgh area) should be aware that their opportunities to move into Carnegie Mellon University housing in the future may be very limited. Students wishing to return to university housing join a wait list for spaces remaining after all returning residents, incoming first-year students and transfer students have been housed.

Community Housing

Housing and Dining Services provides an off-campus housing registry service. This on-line service maintains up-to-date information on available apartments, houses and rooms in private homes for rent, as well as on students who are looking for roommates. Additional information about moving to Pittsburgh, utility companies, etc. is included on the site. Since accommodations in university housing are not available to graduate students, Community Housing Services is a good resource for graduate students seeking accommodations in the local area. For more information on our services, please visit our website at <http://www.cmu.edu/housing/community-housing/>.

Additional housing information can be found in "The Word (<http://www.cmu.edu/student-affairs/theword/>)", "From the Ground Floor Up, the undergraduate guide to Housing and Dining Services" or at www.cmu.edu/housing/

Dining Services

At Carnegie Mellon Dining, our priorities are to give students healthy options, a convenient dining experience and, most importantly, good tasting, quality food. We currently feature over twenty eating locations in the University Center and in residential and academic buildings. Our cuisine ranges from Asian to Indian to American, from an All-you-care-to-eat location to breakfast served all day to a quick sandwich and drink on the go. We have established hours to meet the needs and requirements of the campus community, from early morning coffee to late night snacks. We are able to accommodate special dining needs and have a registered dietician and other food service professionals on campus that can work with individual students on nutrition and diet choices.

Dining Plans

We have designed our dining plans so that you can choose when, where and what you want to eat to best fit your needs. Your dining plan is encoded on your Carnegie Mellon ID card so that you have easy access to your account wherever you go.

There are several different ways to use your dining plan on campus. Our traditional dining plans and community dining plans consist of value meals combined with a declining balance account called flexible dollars. Students are also able to select a DineXtra only plan, which acts as a declining balance account for the entire semester.

Students who have purchased a traditional or community dining plan are able to use meal passes at any dining location. There are four meal periods per day - breakfast, lunch, dinner and late night. You can use one pass during each of these meal periods. The traditional plans also include two guest meals per semester which allow your guests to enjoy campus food with you, or you can use these meals if you would like to purchase two meals during one pass period. These guest meals can be redeemed at any time during the semester.

Flexible dollars and DineXtra are dollars that can be used at any point during the semester. They can be used to upgrade your meal passes with special options like Premium Entrees or to purchase items a la carte at any of our Dining locations. Flexible dollars and DineXtra can also be used at Entropy+, the campus convenience store, to purchase grocery items to supplement your daily meals. In addition to dining locations on campus, they are also accepted at Eat n' Park (Murray Ave), Vocelli's Pizza (Baum Blvd) and Subway (S. Craig St) off campus. Unused flexible dollars do not roll over to the next semester. DineXtra balances do roll over from the fall to the spring semester, but your account expires at the end of the spring semester.

Vending Services

Vending machines are located in a number of locations throughout campus. From this 24-hours service, students may choose entrees, "Healthy choice" lunch meats, soup, coffee, assorted beverages, and snacks. Many of the machines in the residence halls are enabled to accept DineXtra transactions, and most vending machines around campus also accept Plaid Ca\$h. Purchases are made by swiping your Carnegie Mellon ID Card through the card reader on each machine, which will access and deduct the cost of the purchase from your DineXtra or Plaid Ca\$h accounts.

Academic Support Services

Academic Development
Cyert Hall, Suite B5
412-268-6878
www.cmu.edu/academic-development

Academic Development provides a variety of support services geared towards helping students develop the skills, strategies, and behaviors needed to perform as confident, independent, and active learners. These services range from study skills instruction in areas such as textbook reading and lecture note taking to tutoring and review sessions in selected courses. These services are free of charge and available to all Carnegie Mellon students - those who are having difficulties and those who just want to improve their skills.

Following are the services that Academic Development offers:

Peer Tutoring

Peer Tutoring is geared primarily, but not exclusively, toward large introductory courses. It is available from 8:30-11:00pm. Sunday-Thursday in various residence halls and on selected weekday afternoons in Cyert B5. This is a walk-in service, and no appointment is necessary. Standing Tutoring appointments are also available upon request.

Study Skills Instruction

Group workshops are held several times each semester, covering topics such as time management, stress management, test taking, and procrastination. Register for workshops or make individual appointments by contacting Academic Development.

Supplemental Instruction (SI)

Supplemental Instruction (SI) is an academic enrichment program that is offered in traditionally difficult courses. SI discussion and review sessions are facilitated by trained student SI Leaders who have already completed the course and received an A in it.

Designed to supplement - not replace - class lectures and recitations, SI sessions are interactive and collaborative. Students who attend sessions learn to integrate how to learn with what to learn.

SI sessions are usually held twice weekly for one hour; additional sessions are held prior to exams. Attendance at sessions is voluntary.

Study Groups

Organized Study Groups are available in selected courses each term. The Study Groups are limited to six students and are facilitated by a student leader. Come in to the Academic Development office in Cyert Hall, Suite B5 and fill out a Request Form to join a Study Group.

Fast Facts

These pamphlets, which offer tips on a variety of academic success issues, can be picked up from the Academic Development office or can be viewed on the website under "Publications".

Freshmen Fast Facts

This set of five brochures is geared primarily toward freshmen. They cover topics such as working with faculty, optimizing your time, managing coursework and readings, understanding grades, academic integrity, and getting help when you need it.

Teacher Certification

Carnegie Mellon students interested in earning teacher certification can participate in a 5-year program that will allow them to earn their undergraduate degree at Carnegie Mellon and spend one year in an intensive Master of Arts in Teaching (MAT) program at Chatham University to earn the MAT and Pennsylvania Teacher Certification. To make this program possible, interested undergraduate students should plan to cross register at Chatham for 63 units of required courses, using elective spaces in their schedule. Students who will graduate after December 2012 will have slightly different requirements because of changes being made to more adequately meet the requirements of the No Child Left Behind law (mainly related to preparation to work with special education populations and students who speak English as a second language).

Criteria for admission to the MAT program includes: An overall GPA of 3.0, and completion of three pre-professional Praxis exams in Reading, Writing and Mathematics. All candidates for initial certification in Pennsylvania must have earned at least a baccalaureate degree, completed an approved program of teacher education, and passed The Praxis content tests for their certification area. NOTE: Pennsylvania has signed interstate agreements with more than 42 other states, so you are not restricted to teaching in Pennsylvania. Check with the Department of Education in the state where you will live to determine if PA certification will be accepted. To plan early, contact Judith Hallinen, Assistant Vice Provost for Educational Outreach, 8-1498.

Intercultural Communication Center

Peggy Allen Heidish, Director
Warner Hall 308, 412-268-4979
<http://www.cmu.edu/icc>
eslhelp@andrew.cmu.edu

The Intercultural Communication Center (ICC) is a support service offering both credit and non-credit classes, workshops, and individual appointments designed to equip nonnative English speakers (international students as well as students who attended high school in the U.S.) with the skills needed to succeed in academic programs at Carnegie Mellon. In addition to developing academic literacy skills such as speaking, reading and writing, students can learn more about the culture and customs of the U.S. classroom. The center offers:

- Writing Clinic: individual appointments to help students with their academic writing assignments
- Credit class for undergraduates: Building Fluency for Presentations (7 week mini, 99-451); register through ICC, interview required
- Non-credit Seminars and workshops: such as Citing Sources, Writing Academic Summaries and Revising for Clarity
- Tutoring: individual appointments address specific areas such as speaking, listening, grammar, and academic fluency
- Placement interviews: evaluate spoken language so that we can suggest appropriate ICC work and give students useful feedback on the strengths and weaknesses of their communication skills.
- The ITA Test: a mandatory screening test for any non-native speaker of English (graduate or undergraduate) who plans to work as a teaching assistant.

Level of English fluency needed for non-Native English speakers - Please see Academic Regulations. (p. 54)

Fellowships

Fellowships and Scholarships Office (FSO)

Stephanie Wallach, Director
412-268-9987
<http://www.cmu.edu/fso>

Students at Carnegie Mellon are encouraged to apply for a wide variety of national and international fellowships available throughout their undergraduate years and post graduation. These opportunities — some more competitive than others — open up a diverse range of experiences, exposing students to new scholarly communities, to different kinds of research, and/or to service in the public sector. Participation in scholarships, fellowships, and other award opportunities is often an important springboard to future career directions. Many people have heard about the Rhodes Scholarships, the Fulbright Grant and The Harry S. Truman Scholarship, yet there are hundreds of opportunities that may be less well-known but are excellent funding sources.

The Fellowships and Scholarships Office plays an important role in helping students learn about scholarships that are a good match for their interests. The FSO staff also work closely with students on their applications to make sure that they are as competitive as possible.

Please visit the FSO website to learn about the many scholarships and fellowships open to Carnegie Mellon students. The website also contains useful links to other resources for additional information on external educational opportunities.

Honor Societies

Phi Beta Kappa Society

Carnegie Mellon shelters a chapter of the Phi Beta Kappa Society, sponsored by the three colleges (Dietrich College of Humanities and Social Sciences, Mellon College of Science, and the School of Computer Science) that comprise the University's "arts and sciences" equivalent. The chapter's name is "Upsilon of Pennsylvania," and was formally installed in April of 1995.

Founded in 1776 at the College of William and Mary in Williamsburg, Va., Phi Beta Kappa is the nation's oldest honorary society, with chapters at 276 of the foremost institutions of higher education across the country. Almost all members are elected by the chapters from among candidates for degrees in liberal arts and sciences, usually from the top 10% of the graduating class.

Many notable figures in American History have earned the coveted Phi Beta Kappa key including leaders of the American Revolution, delegates to the Constitutional Convention of 1788, and members of the Continental Congress and the U.S. Congress. Six United States presidents earned the honor as undergraduates and another 10 presidents were elected as alumni or honorary members.

Membership in Phi Beta Kappa key has become a universally recognized mark of academic achievement in the liberal arts and sciences. The key's venerable pointing finger proclaims for all to see the wearer's commitment to Phi Beta Kappa's ancient principles (represented in the three stars) — friendship, morality and learning.

The society's name is formed by the first letters of the phrase *Philosophia Biou Kybernetes*, Philosophy (wisdom) is the Guide of Life. In line with the conviction that the test of education lies not in what people know but in what they are, the objectives of humane learning encouraged by Phi Beta

Kappa include not merely knowledge but also intellectual honesty and tolerance, a broad range of intellectual interests and understanding.

The Carnegie Mellon chapter is active in sponsoring visiting speakers, on-campus roundtables that focus on current issues, community service activities, scholarship opportunities, student research involvement, and the like.

The Honor Society of Phi Kappa Phi

The Honor Society of Phi Kappa Phi has been an important presence on campus since 1933. Phi Kappa Phi, a national honor society that began in 1897 at the University of Maine, takes its name from the initial letters of its adopted motto, *Philosophia Kratoito Photon*, "Let the love of wisdom rule humanity." Phi Kappa Phi recognizes and honors persons of good character who have excelled in scholarship, in all fields of study. Members are nominated by their department or their school or college and then invited to join the society. To be eligible, seniors must be in the top ten (10) percent of their class and juniors in the upper seven and one-half (7.5) percent of their class at the time of invitation. Graduate students, alumni, faculty and staff are also eligible for nomination. The chapter inducts new members once a year, each spring, and provides information to its members on all sorts of opportunities, including study abroad, internships, and graduate fellowships, recognition and awards.

Undergraduate Research Office

Stephanie Wallach, Assistant Vice Provost for Education
www.cmu.edu/uro

What is the Undergraduate Research Office (URO) at Carnegie Mellon?

Conducting research as an undergraduate is a terrific way to get to know faculty members, explore an area of interest in depth, turn classroom theory into practical hands-on experience, get a feel for graduate school, and have some fun at the same time! The Undergraduate Research Office supports students conducting independent research and creative projects in every field at the university.

All undergraduates at Carnegie Mellon are eligible to participate in Undergraduate Research Office programs. The term "research" is defined broadly as "research, scholarly, or artistic activities that lead to the production of new knowledge; to increased problem solving capabilities, including design and analysis; to original critical or historical theory and interpretation; or to the production of art or artistic performance." Students from all fields and at all levels are encouraged to participate in the research process at least once, and hopefully many times, in their undergraduate careers. Our website, www.cmu.edu/uro contains detailed information on all of our programs and on the application processes.

Advising and Information Services

The Director and Assistant Director of the Undergraduate Research Office are available to discuss project ideas; suggest possible faculty mentors (required); read and comment on proposal drafts; and generally facilitate the research process. In addition, the URO typically runs two proposal writing workshops each semester to assist students in preparing their proposals. Support from the URO is a competitive process and requires the students to submit strong proposals

Small Undergraduate Research Grants (SURG)

Undergraduates in good academic standing are eligible to apply for a Small Undergraduate Research Grant (SURG). Awards are made twice each year based on submitted project proposals. A panel of faculty and administrators from each of the colleges serves on the selection committee and will generally consider requests up to \$500 for individual student projects or \$1000 for a group project. Grants may be used to purchase supplies and materials, rent time on laboratory equipment, pay subjects in an experiment, or even travel to another city to collect data. Budgets are required as part of the SURG proposals. Deadlines are October for the Spring grant period and in March for the Summer and Fall grant periods.

Summer Undergraduate Research Fellowship (SURF)

These fellowships are designed to allow students a 8-10 week summer of supported research at Carnegie Mellon in close collaboration with a faculty advisor. Students receive a fellowship of \$3,500 as a stipend to cover any of their expenses. The deadline for submission of proposals coincides with the regular SURG deadline in March.

Undergraduate Research Symposium: Meeting of the Minds

The undergraduate research symposium, known as "Meeting of the Minds," is an annual event that brings our campus together to celebrate the diverse, creative, and ground-breaking research that takes place among undergraduates. Students share their research findings through poster, oral, and artistic presentations. Many participate in award competitions sponsored by various corporations, individuals, and organizations. All students funded through the URO are required to attend, but it is also open to other students, including senior thesis presenters. Approximately 450 students participate each year. Meeting of the Minds takes place during early May at the University Center.

Presentation Awards

Students whose work has been accepted for presentation at an academic conference are eligible to apply for a Presentation Award. These awards, up to \$250, help defray costs of conference registration, transportation, and accommodation.

SRC-URO Program

Second-year students in semiconductor research and information technology fields are eligible to join faculty labs — depending on the needs of the faculty and qualifications of the student — to get an early taste of the excitement and benefits of undergraduate research. The Semiconductor Research Corporation funds this program. Students can earn up to \$2,000 per semester for the second semester of their sophomore year and for both semesters of their junior year; they are strongly encouraged to apply for SURF (\$3500) for the summer between their sophomore and junior years. SRC-URO is open to students in the following fields: Electrical and Computer Engineering; Chemical Engineering; Mechanical Engineering; Materials Science and Engineering; Computer Science; and Physics. This is a competitive opportunity and the number of participants is very limited. A special application process is required and is available on the URO website.

University Center

Carnegie Mellon's University Center is the first building of its kind on our campus. A central gathering place for all members of the university community, the University Center is the hub of Carnegie Mellon's social, athletic, recreational and religious life.

- Play basketball, volleyball and badminton
- Play racquetball or squash on one of five courts
- Swim in the eight-lane lap pool or dive into the diving well
- Work out on new weight machines, rowers, stair climbers, ellipticals, and treadmills
- Take a group exercise class including yoga, indoor cycling, Pilates, and Zumba. Check the website www.cmu.edu/athletics/facilities/university-center.html for further information.

The locker rooms include showers, whirlpools, and steam rooms.

Eating at the University Center

We've brought in several outside vendors to offer a variety of dining options:

- City Grill
- Creperie
- Downtown Deli
- El Gallo de Oro
- entropy+
- Evgefstos
- Pasta Villagio
- Quik Piks
- Schatz Dining Room
- Skibo Coffeehouse
- Spinning Salads
- Take Comfort Too
- The Pomegranate

Shopping at the University Center

Carnegie Mellon's retail stores are in the University Center. These include the Art Supply Store and the University Shoppe, a multi-level retail facility for art/engineering supplies and tools, books, textbooks, clothing, memorabilia and the computer store.

The building houses student organization offices, activity space and the Scotland Yard Game Room. The game room includes pool tables, foosball,

ping pong and shuffle board. The building also includes the Student Activities staff offices, webstations and printer, a multi-denominational chapel, a prayer room, the University Post Office, a recycling room, FedEx Office, ATMs, PNC bank branch, the Career and Professional Development Center and an alumni lounge, which is open to all members of the university community.

University Police

Thomas Ogden, Chief
300 South Craig Street, Room 199
Public entrance on Filmore Place
www.cmu.edu/police

The University Police Department consists of 24 sworn Police Officers, 37 Security Guards, and five Communications Dispatchers. University Police provides campus buildings and grounds patrol, emergency medical transport, personal escorts, and other services to increase the safety and well being of persons and property in the university community. Officers patrol the campus continuously 24 hours a day, seven days a week on foot, on bicycle and in vehicles and remain in constant radio contact so that they can respond rapidly in the event of an emergency. Direct line emergency telephones to the University Police communications center are located both inside and outside of buildings at 53 locations around the campus.

All crimes that occur on campus should be reported immediately to University Police to ensure that appropriate action is taken. Crime occurring on campus can be reported in person, or by calling the University Police emergency number, (412) 268-2323 or x8-2323, any time of the day or night. All other non-emergency inquiries should be made by calling the non-emergency number (412) 268-6232 or x86232.

University Police operates an Operation Campus Watch program to increase the awareness of the entire community at Carnegie Mellon. The concept of Operation Campus Watch includes two simple aims:

1. The sharing of crime information by University Police.
2. The involvement of the entire community in reporting suspicious activity or actual crime.

Additional information on Operation Campus Watch is available at the University Police Office located in Room 199, 300 South Craig Street or by calling the non-emergency number, (412) 268-6232.

All emergencies on campus, including fire and medical, should be reported immediately to University Police.

Students are responsible for their personal property as well as the property of groups to which they belong. Insurance against loss, theft, or damage to such property occurring in the residence hall or elsewhere on campus must be arranged for by students or their parents through an insurance agent.

University Police makes available on the world wide web a wide range of information about the university's security practices. Descriptions of crime prevention programs, alcohol and drug, sexual assault policies, and statistics about the number and type of crimes committed on campus during the preceding three years can be found at www.cmu.edu/police, click on "Annual Reports."

University Libraries

Keith Webster, Dean of University Libraries
Hunt Library
412-268-2447
kwebster@andrew.cmu.edu
www.library.cmu.edu

Facilities and Services

The University Libraries' collections support teaching and research at Carnegie Mellon University (CMU). The collections for various disciplines are housed in three libraries: the Engineering and Science Library (engineering, mathematics, physics, computer science and robotics), Hunt Library (humanities, fine arts, social sciences and business) and the Mellon Institute Library (chemistry and biology). An off-site storage facility holds low-circulating materials, which are available at your request via the library catalog. Interactive access to library resources is supported by the University Libraries' home page at <http://search.library.cmu.edu>.

Reference services help you to select resources and find the information you need. If you need materials that we do not own, interlibrary loan will help you to obtain them. Circulation services help you to borrow and renew materials, and use course reserves. Most course reserves are online, but some reserves are hard copies that faculty set aside in the library for their classes to use.

The University Libraries also house several unique collections (Architecture Archives, Fine and Rare Books, and the University Archives) in addition to a number of special collections that we have digitized and make available online. Digital collections include the H. John Heinz III Archives, the Allen Newell Collection, the Clifford Shull Collection, the Herbert Simon Collection, the Joseph Traub Collection, and the Posner Family Collection of fine and rare books. Student-created exhibits of fine and rare books from the Posner Collection are a regular feature in Posner Center, located between the College of Fine Arts and the Tepper School of Business.

Online Access

From the Libraries' home page, search.library.cmu.edu:

- CAMEO library catalog - Use CAMEO to find out where materials are located in libraries on campus. See whether items are checked out, on reserve, or available to be borrowed.
- My Library Account - Renew books, put books on hold, see a list of what you have checked out, see fines.
- Course Reserves - Find required materials that your professors have reserved for classes to use.
- Research Help - Learn about key resources in your subject area, including the CMU librarian who is a subject specialist for your school or college.
- Ask Andy - Interactive reference service staffed by CMU librarians (chat, IM, email, phone, or in-person)
- AND MUCH MORE: Library Collections - Articles & Databases - E-Journals A-Z - Library Catalogs - Library Services ...

"Library Catalogs" links to online catalogs for the University of Pittsburgh Library System, The Carnegie Library of Pittsburgh, and other local libraries. We are partners with Pitt and The Carnegie; you can get library cards and borrow directly from these nearby libraries.

Instruction and Help - Live!

Get acquainted with the collections and services that support your school and subject area. Take advantage of library orientations and other library instruction classes that will help you become adept at using information resources. Being able to select good sources, access information efficiently, and evaluate results are skills that you will use throughout your academic and professional career.

Reference desks at the Engineering and Science Library, Hunt Library, Mellon Institute Library and in Arts and Special Collections (at Hunt Library) are staffed weekdays, evenings, and on weekends. Besides helping you in the library, reference staff also can answer your questions about remote access (using library resources such as databases and e-journals from any internet location).

If you need specialized reference help, contact the librarian for your subject area. Librarians work directly with faculty and students in each school, department and institute at CMU to help shape library collections, teach library research skills, and assist efficient research.

Undergraduate Jobs

The University Libraries hire many undergraduate students each year, primarily through state and federal work/study programs. Working part-time in the library gives you the unique opportunity to learn and practice skills that will contribute to academic success while you earn some spending money. If this sounds interesting to you, check out [About Us > Employment> Student Assistants at \[search.library.cmu.edu\]\(http://search.library.cmu.edu\)](#) and apply.

Undergraduate Options

This page describes some of the many options of study students can choose during their undergraduate career at Carnegie Mellon.

Additional Majors/Dual Degrees

Students interested in pursuing more than one area of study are encouraged to consider an additional major or dual degree. Students who complete an additional major will earn a single degree in two areas. Generally, it is possible to fulfill the requirements of both majors in four years by taking the course requirements of the second major in the elective spaces allowed by the first major. Students in Carnegie Institute of Technology may elect to double major in Engineering and Public Policy or Biomedical and Health Engineering, which are offered only as an additional major. Human Computer Interaction is also offered only as an additional major.

Dual Degree programs allow students to earn two degrees. Students who are interested in an additional major or dual degree are encouraged to review the specific possibilities with the relevant academic advisor.

Five-Year Bachelor's/Master's Programs

Qualified undergraduates may apply to one of several programs to earn their bachelor's and master's degrees in five years. For further details about these programs, please refer to the appropriate college or departmental section(s).

Carnegie Institute of Technology

The five-year Integrated Master's/Bachelor's programs offered by the Departments of Electrical and Computer Engineering and Civil and Environmental Engineering offers students superior technical preparation for careers in industry. The Departments of Chemical Engineering and Mechanical Engineering also offer fifth year/Accelerated Masters programs. The Department of Materials Science and Engineering offers a cooperative Industrial Internship Option in which students alternate coursework with practical experience in industry. Admission is highly competitive and leads to a Master of Science degree.

Dietrich College of Humanities and Social Sciences

The Department of Philosophy offers a bachelor's/master's degree option: the Bachelor's/Master's degree in Logic and Computation. The M.A. in Teaching English to Speakers of Other Languages (TOESL) is a fifth year master's option for Modern Language students who are concentrating in English as a Second Language. Also, the department of English offers an accelerated program for undergraduates to obtain a Master of Arts in Professional Writing.

H. John Heinz III College

The Heinz College's Accelerated Masters program allows qualified undergraduate students to earn a prestigious Master of Science degree in Public Policy and Management. For students in the College of Fine Arts or the Bachelor of Humanities and Arts degree program who are interested in careers in arts management, the program leads to a Master of Arts Management degree.

Mellon College of Science

The Honors Programs in the Departments of Chemistry and Mathematics are demanding, accelerated programs that give highly qualified students the opportunity to earn their bachelor's and master's degrees in just four years. Admission is by invitation only.

Tepper School of Business 3-2 Program

Students who are interested in business management may wish to consider the Tepper School of Business 3-2 program. Qualified undergraduate students may earn their Master of Business Administration in addition to their bachelor's degree.

Health Professions Program

Director: Jason D'Antonio
Office: Doherty Hall 1319

The Health Professions Program (HPP) at Carnegie Mellon University is an advising and resource center for all university students and alumni who are interested in one or more aspects of the health professions. This program complements a student's curricular advising and is meant to help students explore their interests, prepare for graduate programs in the health professions, and facilitate their application process. Students can enroll in the program at any time during their academic career, but the importance of early planning is communicated to interested first-year students. Once enrolled, students meet regularly with the director to discuss course requirements, medical exposure opportunities, and other aspects of preparing to be a competitive candidate.

Students in the HPP span all colleges of the university and have many diverse career interests including medicine, dentistry, optometry, biomedical research, medical physics, rehabilitation engineering, medical informatics, and health policy. Although the majority pursue a primary major in the Mellon College of Science, other highly represented disciplines include engineering and the social sciences.

Regardless of a student's major, the basic course requirements outlined below must be completed prior to medical school matriculation, and most should be taken before the student takes the Medical College Admissions Test (MCAT) that is normally taken in spring of the junior year:

1. One year of general biology with lab.

This is typically fulfilled by the following Carnegie Mellon courses:

03-121	Modern Biology	9
03-230	Intro to Mammalian Physiology	9
or 42-202	Physiology	
03-124	Modern Biology Laboratory	9-12
or 03-343	Experimental Techniques in Molecular Biology	
or 03-206	Biomedical Engineering Laboratory	

2. One year of general chemistry with lab.

This is typically fulfilled by the following Carnegie Mellon courses:

09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-221	Laboratory I: Introduction to Chemical Analysis	12

3. One year of organic chemistry with lab.

This is typically fulfilled by the following Carnegie Mellon courses:

09-217	Organic Chemistry I	9
09-218	Organic Chemistry II	9
09-222	Laboratory II: Organic Synthesis and Analysis	12

4. One year of physics with lab.

This is typically fulfilled by the following Carnegie Mellon courses:

33-106/111	Physics I for Engineering Students (for science or engineering students)	12
33-112	Physics II for Science Students	12
33-100	Basic Experimental Physics	6

5. One year of English.

This is typically fulfilled by the following Carnegie Mellon courses:

76-101	Interpretation and Argument	9
76-xxx	English course of the student's choice, typically 200-level or higher	

In addition to these general course requirements, recommended coursework includes calculus, biochemistry, statistics, behavioral sciences, ethics, and languages. Interdisciplinary studies are also strongly encouraged, and many students design an undergraduate curriculum that incorporates

majors and/or minors in both the natural and social sciences. One interesting interdisciplinary minor offered is the Minor in Health Care Policy and Management, which broadens awareness of the health care field from social, economic, historical, and policy perspectives. See <http://coursecatalog.web.cmu.edu/melloncollegeofscience/melloncollegeofscienceminors/> for the details of this minor.

Undergraduate research is a hallmark of the educational experience at Carnegie Mellon in many disciplines. Whether in the psychology lab studying the impact of breast cancer diagnosis on family social dynamics, in the NMR lab imaging metabolic function in the heart or brain, or in the surgery suite testing robotic devices, our students have made significant achievements in research, well beyond the more traditional guided experiments.

Our university policy is to train students to be first class scientists, engineers, artists, writers, managers, or whatever their passion may be. We do not train students to be “pre-med,” but if they choose to use their talents in a health profession, we offer many services to help them obtain their life goals. Regular advising, application workshops, health issue seminars and symposium, community outreach activities, and preceptorship/ internship experiences are all part of our programming. The student pre-health organizations on campus, the Doctors of Carnegie (DOCs) and the Minority Association of Premedical Students (MAPS), together with the Health Professions Program, provide students with many opportunities to learn, explore, and prepare for their chosen area of professional interest.

The Health Professions Program has been successful in helping students to define, prepare for, and obtain their professional goals. Our students are regularly accepted at top-level medical and graduate programs, and our alumni continue to serve as outstanding ambassadors of Carnegie Mellon and the training and experience they received here.

Minors

In addition to a student's primary degree, he or she can choose a minor, a secondary focus to the student's area of study, which can enhance a student's breadth of study and overall experience while not requiring the same amount of coursework as a second major or degree. The following list shows available minors. Unless otherwise indicated, minors are generally open to all university undergraduate students.

Intercollege:

- Arts in Society (sponsored by the Center for Arts in Society)
- Health Care Policy and Management (sponsored by the College of Humanities and Social Sciences, the H. John Heinz III College, and Mellon College of Science)
- Music Technology
- Neural Computation

College of Engineering:

The following Engineering minors are open to all Carnegie Mellon students::

- Biomedical Engineering
- Engineering Studies
- Technology and Policy
- Robotics

Designated Minors (open only to Engineering students):

- Audio Engineering
- Automation and Controls
- Colloids, Polymers and Surfaces
- Data Storage Systems and Technology
- Electronic Materials
- Environmental Engineering and Sustainability
- Global Engineering
- Materials Science and Engineering
- Mechanical Behavior of Materials

College of Fine Arts:

- Accompanying (available only to Piano majors in the School of Music)
- Architectural Representation and Visualization (available also to B. Arch candidates)
- Architectural Technology
- Architecture
- Architecture History (available also to B. Arch candidates)
- Art

- Building Science (available only to B. Arch candidates)
- Communication Design
- Conducting (available only to students in the School of Music)
- Drama
- History of the Arts
- Industrial Design
- Music
- Music (Composition) (available only to students in the School of Music)
- Music Education (available only to students in the School of Music)
- Music Performance (available only to students in the School of Music)
- Musicology
- Music Technology
- Music Theory
- Photography
- Sound Design

Dietrich College of Humanities and Social Sciences:

- African and African American Studies
- Anthropology
- Chinese Studies
- Cognitive Neuroscience
- Creative Writing
- Economics
- English
- Environmental Studies
- Ethics
- Film and Media Studies
- French and Francophone Studies
- Gender Studies
- German Studies
- Global Systems and Management
- Health Care Policy and Management
- Hispanic Studies
- International Relations and Politics
- Japanese Studies
- Linguistics
- Logic and Computation
- Philosophy
- Policy and Management
- Politics and Public Policy
- Professional Writing
- Psychology
- Religious Studies
- Russian Studies
- Science, Technology and Society
- Social & Political History
- Sociology
- Statistics
- Technical Writing

Mellon College of Science:

- Biological Sciences
- Chemistry
- Computational Finance
- Discrete Mathematics and Logic
- Environmental Science
- Mathematical Sciences
- Neuroscience
- Physics
- Scientific Computing

School of Computer Science:

- Computational Biology
- Computer Science
- Human-Computer Interaction
- Language Technologies
- Machine Learning
- Robotics

- Software Engineering

Tepper School of Business:

- Business Administration
- Innovation and Entrepreneurship

IDeATe

The Integrative Design, Arts and Technology (IDeATe) network offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students will engage in active “learning by doing” in state-of-the-art maker spaces. The program addresses current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDeATe undergraduate curriculum consists of eight interrelated concentration areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and arts:

- **Game Design:** Enhance your knowledge of key component areas of games such as dramatic narrative and character development, programming and engine development, game assessment and redesign. Create games for varied platforms from mobile devices to home entertainment systems and theme parks.
- **Animation & Special Effects:** Explore the technical and artistic aspects of 3D and 2D animation in an integrated manner and within different application contexts (from film animation and special effects to interactive displays).
- **Media Design:** Learn to design digitally mediated experiences across different platforms, from mobile apps to large-scale installations, and for varied applications (from media for daily living to mediated performances).
- **Learning Media:** Design effective new media systems for learning using new technologies, learning science principles and media arts knowledge. Produce engaging and effective experiences from games to tangible learning tool kits and remote systems.
- **Sound Design:** Create experimental music or explore new, technology-enabled applications and markets for sound design, music creation, and performance.
- **Entrepreneurship for Creative Industries:** Lead and innovate in creative industries through coursework that emphasizes the conceptualization of innovative products and the structuring of innovation processes.
- **Intelligent Environments:** Develop spaces and devices that support efficiency and high quality of experience, in contexts like daily activity, built environment, making process (from laying plaster to robot development), and arts performance.
- **Physical Computing:** Build interfaces and circuitry to embed in physical contexts, such as mobile environments and new creative practice instruments.

Individuals who make significant contributions, academically and professionally, in these areas are solidly prepared in a related discipline. Their preparation is combined with the ability to work in multidisciplinary teams that span technology and the arts. IDeATe serves as a multidisciplinary collaborative learning addition to the education (and learning outcomes) that students receive through their disciplinary major rather than a standalone learning experience.

Innovation and advancement in the eight IDeATe concentration themes, as in many complex areas of inquiry, is the result of collective inquiry and requires deep expertise in all contributing areas of knowledge (i.e. expert technologists and artists). Carnegie Mellon University is the only University in the United States with top ten ranked units in all key technological and arts domains involved in the eight IDeATe concentrations. With these resources, CMU is uniquely positioned to create faculty and student teams that contain all necessary, high-level expertise in tech-arts areas of inquiry.

Students who participate in IDeATe will be able to combine the unique experience of a “deep dive” in their chosen discipline while connecting to the diverse areas of knowledge and skill across the university. To help facilitate this experience, the educational objectives of the IDeATe concentrations and minors are:

- Students from any undergraduate major can integrate a tech-arts area of study into their curricular plan and professional exploration through the IDeATe concentrations/minors, which enhance and synthesize the tech-arts ecosystem at CMU.
- Students in IDeATe have the opportunity to:
 - Immerse themselves in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology
 - Engage in active “learning by doing” in state-of-the-art maker spaces
 - Address current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and integrative approaches.

A student can choose to enroll in an IDeATe concentration (or minor) either in their sophomore or in their junior year. To complete a concentration the student will take 4 courses (five for a minor): one cross-training course, two courses in their chosen concentration theme (three for a minor), one course from a different concentration theme. To complete a minor, at least three of the courses taken cannot be double counted for the major degree (all courses of a concentration can count towards the major degree).

Across the eight concentration themes there are over 50 multi-disciplinary technology-arts courses that a student can choose from to customize their paths. Students are assisted in their choice of theme area and in the structuring of their path by a dedicated IDeATe advisor who works in tandem with the advisor in their home unit.

The *cross-training courses (portal courses)* introduce students to the concepts and practices of knowledge areas beyond their discipline that contribute to the subject of each minor/concentration. After completing the portal courses, students should be able to (1) interpret cross-disciplinary communication from their collaborators (and use that interpretation productively in the collaborative work), (2) translate their own disciplinary expertise to describe ideas and outcomes in a way their cross-disciplinary collaborators can understand, and (3) develop interdisciplinary tech-arts prototypes (that include perspectives from multiple disciplines and enable further interdisciplinary communication and collaboration).

The remaining courses of IDeATe are *Collaborative studios*. Each studio is focused on a key aspect of the minor/concentration that it’s categorized under. By taking three studios in the minor/concentration the student can become familiar with many of the technical and creative issues in the area of the minor and the collaborative processes they entail. The student can also explore the interrelations of these studios. These courses are branded as collaborative studios because a) they promote hands on learning through making, critique and iterative design, b) they promote learning from both the instructor and the interdisciplinary peer cohort. At the conclusion of each studio a student should be in a position to a) collaboratively plan and implement an established outcome in the area of the studio within a limited amount of time and b) apply skills from both technology and arts disciplines to prototype ideas and leverage the diversity of perspectives to produce innovation in the field.

A completion of a concentration should provide multidisciplinary training in the area of the concentration and furthermore *enhance collaborative learning experience and skills of students*: diversify the cohorts of the student, enhance collaboration skills, promote cognitive versatility, facilitate skill transfer across technology and the arts, and produce graduates that can innovate in 21st century creative industries.

Students completing an undergraduate degree with an IDeATe concentration have the opportunity to apply for enrollment in the cross-University Emerging Media Masters degree and complete the degree in one year (4+1 Media Master’s option).

For more information, please visit the IDeATe website (<http://www.cmu.edu/ideate>).

Pre-Law Advising Program

Director: Joseph Devine, Associate Dean for Undergraduate Studies, Dietrich College

Office: Dietrich College Dean's Office, Baker Hall 154
www.cmu.edu/pre-law

"Law School" is an objective that students frequently mention when asked about post-baccalaureate plans. It seems in its brevity to be a simple enough answer, but in reality it masks a host of complex and momentous personal decisions and strategic tasks.

First and foremost, seeking entry into law school implies an informed decision about the rigors of law school and the realities of professional life as an attorney, as well as a strong and mature commitment to achieving these objectives at significant cost and investment (financial, personal, and intellectual). Second, it implies an understanding of the prolonged sequence of steps involved in the process of selecting law schools to which to apply, actually applying, ultimately selecting a school to attend, financing a law school education, and succeeding in law school. Finally, it implies an understanding of this as one of many options that should be carefully considered before a choice is made that will so significantly influence the course of one's personal and professional life.

To address these needs, the university offers a pre-law advising program for students and alumni/ae who are contemplating or actively seeking to enter law school. The program consists of a range of support services, coordinated centrally, designed to assist these groups in engaging the complex questions associated with decisions about law school, and in successfully negotiating the sequence of tasks associated with selecting, applying and gaining admission to the best law schools possible.

The emphases of this program are:

- early identification of pre-law candidates;
- stimulation at early stages and throughout this process to consider the essential questions of personal suitability for law school and professional life as an attorney;
- engagement with meaningful substantive issues rooted in the law that illustrate the intellectual complexities of our legal system and the corresponding intellectual acumen needed to enter and thrive in this profession;
- timely direction in designing and executing a well-planned law school research, selection and application strategy;
- gathering and using accurate data on university alumni entering law school and the legal profession.

The program proper consists of several components, organized and made available as an ongoing service to all students and graduates of the university. These components include periodic workshops and seminars, a pre-law web site, a pre-law newsletter, and linkage with law school admissions offices, the Law School Admissions Council, and associations (both regional and national) of pre-law advisors. The program also works closely with the student Pre-law Society.

Two early admission options are available to Carnegie Mellon undergraduates interested in either of Pittsburgh's two law schools: the Duquesne University School of Law, and the University of Pittsburgh School of Law. Requirements and procedures vary for each option. Interested students should meet with the university pre-law advisor before the end of their junior year.

Department of Athletics & Physical Education

Please see Department of Athletics & Physical Education (p. 71).

Reserve Officers' Training Corps (ROTC)

Please see Reserve Officers' Training Corps (ROTC) (p. 73).

Study Abroad

Carnegie Mellon students from every major may be able to study in any part of the world for a semester, year or summer. Short-term programs during spring and winter break are also possible. A well planned study abroad program, in coordination with one's academic advisor, will allow a student to receive credit for study abroad and graduate on time. Most students study

abroad during their junior year; however, a growing number of students are studying abroad during their sophomore and senior years.

The study abroad advising staff offers general information sessions as well as individual advising appointments to assist students in all stages of the study abroad process. The Office of International Education (OIE) has a large in-house library as well as useful web links to help students find the most appropriate study abroad program. In addition, OIE offers orientations to help with personal, academic and acculturation issues, before and after a study abroad experience.

Carnegie Mellon offers students a variety of payment options for study abroad to allow students to study abroad regardless of financial need. There are three categories of programs: Exchange Programs, Sponsored Programs, and External Programs. A description of each program follows. More detailed information can be found at www.cmu.edu/studyabroad.

Exchange Programs

Students who participate in exchange programs pay Carnegie Mellon tuition and receive their regular financial aid package. Students are responsible for room, board, travel and miscellaneous expenses.

University Exchanges

Carnegie Mellon University has university-wide exchange programs with institutions located in Australia, Chile, Hong Kong, Israel, Japan, Mexico, Qatar, Singapore, and Switzerland.

Departmental Exchanges

Architecture, Art, Chemical Engineering, Design, Drama, Electrical and Computer Engineering, English, Heinz College, Information Systems, Materials Science and Engineering, Modern Languages, Computer Science and Business offer departmental exchange programs. Students should contact their department or the study abroad website for additional information.

Sponsored Programs

The university has designated a few study abroad programs administered by other organizations or universities as sponsored programs. To participate in these programs students pay a university fee equivalent to current tuition, room and board, and retain their eligibility for all financial aid. Carnegie Mellon in turn pays the program costs to the study abroad sponsor. Where applicable, funds are distributed to the student for room, board, travel, and personal expenses.

Currently Carnegie Mellon has 38 sponsored programs available around the world. A full list can be found at www.cmu.edu/studyabroad or in consultation with a study abroad advisor.

External Programs

Students may also participate in a program sponsored by another university or study abroad organization if the student's home department approves the program and its course offerings. Students will pay the other organization or institution directly. Students who receive institutional aid from Carnegie Mellon will not be eligible for this aid while they are abroad. However, students with state and federal aid will still qualify. Students can learn more about external program options during study abroad advising appointments and by exploring the study abroad website and library.

University Student-Defined Major

Carnegie Mellon offers the opportunity for undergraduate students to pursue a University Student-Defined Major. (There are also opportunities to pursue a Student-Defined Major in some of the colleges [see relevant college section of the catalog]). For information and advice, interested students are encouraged to speak to the Associate Dean (sic) of their current home college or the college most relevant to the proposed course of study.

The requirements for successful completion of a University Student-Defined Major include a student proposal approved by an advisor, relevant college(s), and the Provost, and successful completion of the approved course of study. In brief:

- A student interested in pursuing a university student-defined major must develop a proposal which outlines an intellectually coherent area of study (with degree title) and a plan of study (courses to be taken, pedagogical rationale, proposed schedule). The proposal should include an explanation of why it is not appropriate or possible to pursue such a program through the curriculum of any one of the colleges. It should outline a program of study for both general education (for example, the

core requirements of one of the most relevant colleges or equivalent general education plan) and major requirements. The proposal should designate one of the participating colleges as defacto "home college" for tracking and verification purposes.

- The student's proposal must be approved by a faculty advisor within a college who takes pedagogical responsibility for the program, by the de facto "home college" and by any other colleges involved in granting the degree. The signed proposal will be submitted to the Provost's office for a final review and approval.
- Once approved by the faculty advisor, colleges, and the Provost's office, the student's major will be administered by the advisor and his/her progress tracked by the Dean's office of the "home college." The "home college" will be responsible for monitoring the student's progress and reminding any collateral colleges of the approval of the student-defined major so that these colleges may insure the student's ability to enroll in the necessary courses. Upon successful completion of the course of study, the "home college" will be responsible for contacting all the relevant colleges and verifying the completion of the degree. Unless there are sufficient numbers of university student-defined majors in any graduation year, upon consultation with the "home college," students may chose to receive the diploma in the most relevant department's ceremony.

Department of Athletics and Physical Education

Susan Bassett, Director of Athletics
Office: 204 Gymnasium
<http://www.cmu.edu/athletics/physed/>

Intercollegiate Athletics

Carnegie Mellon emphasizes excellence in its intercollegiate athletic programs as well as in its classrooms. The University strongly believes that academic and athletic excellence can successfully coexist. It also believes that intercollegiate athletics are important in student life and can become a key part of the educational experience. Professional and social endeavors after graduation also benefit from university experiences as a student-athlete.

Carnegie Mellon sports teams have competed intercollegiately since the early 1900s. In the past 15 years, the program has experienced extensive success. The Tartans have won 81 conference championships and competed in over 108 national championships since 1976. This success has been achieved while meeting all of the academic requirements of demanding programs and without athletic scholarships.

In 1986, Carnegie Mellon became a charter member of the University Athletic Association (UAA), a nine-team league of similar institutions with regard to academic and athletic programs. The UAA, a national association which geographically reaches as far north as Massachusetts, as far south as Atlanta and as far west as St. Louis and Chicago, sponsors intercollegiate competition in 24 sports including 12 for men and 12 for women. UAA members include Brandeis University, Case Western Reserve University, Carnegie Mellon University, Emory University, New York University, the University of Chicago, the University of Rochester and Washington University in St. Louis.

Carnegie Mellon, like the other seven UAA members, is a member of the National Collegiate Athletic Association (NCAA). Its intercollegiate teams compete on the Division III level, which prohibits athletic scholarships and operates under the true meaning of amateurism. Student-athletes who play at the varsity level are students first and athletes second. All students, both athletes and non-athletes, are treated equally with regard to admission and financial aid policies. Carnegie Mellon fully supports a policy of equity in resources and opportunities for women and men.

The university fields competitive teams in 17 sports. The Tartans compete in football, men's and women's soccer, men's and women's cross-country, men's and women's tennis, women's volleyball, men's and women's basketball, men's and women's swimming, men's and women's indoor and outdoor track and field, and golf.

Carnegie Mellon's intercollegiate program has consistently produced winners. The Tartans' football team has won 15 conference championships, has a string of 33 consecutive winning seasons, and has appeared in the NCAA Division III Championship playoffs six times. In 1979, Carnegie Mellon was awarded the Lambert Trophy as the best small college team in the northeast. The men's cross country won the conference championship in 2005 going on and placing 8th at nationals that same season. The team also has had a 12th and 9th place finish at nationals. The women's cross country won the 1998 conference and went on to place 4th nationally.

A freshman computer science major on the men's tennis team won the NCAA National singles title in 2000 and Carnegie Mellon's top doubles team also was selected to play in the nationals. The men's program garnered their highest team ranking ever in 2006 at 11th nationally. The women's tennis team has recently produced national ranked players in the NCAA competition and in 2005 had a sophomore claim the ITA National Small College Championship while earning the James O' Hara Sargent Sportsmanship Award. Both men's and women's swimming and track and field teams annually qualify a number of athletes for the national championships. Swimming recently has produced a national champion and the men's track and field team has won back-to-back conference championships.

To provide excellence in the athletic program, the department employs full-time coaches in all varsity sports. Intercollegiate competition begins with the first football and soccer games in early September and ends with the UAA track and field, golf and tennis championships in late April. Students with athletic skills in any of the above mentioned sports are welcome to become members of the team. Participation is open to all students. Inquiries may be directed to the appropriate coach at the:

Department of Athletics, Skibo Gymnasium
Carnegie Mellon University
Pittsburgh, PA 15213
(412) 268-8551

Recreation

In addition to providing for its more formal programs and teams, Carnegie Mellon's athletic facilities are available for use by individual students on an extensive seven-day per week schedule.

The Skibo Gymnasium, has facilities for basketball, volleyball, badminton, weight lifting, and cardio equipment. Located within the University Center are facilities for squash, basketball, racquetball, volleyball, badminton, a diving pool and a large swimming pool for lap swim, cardio machines like treadmills, Espresso Bike EFX, steppers, Cybex machines, dumbbells, a sauna and a whirlpool. Gesling Stadium provides soccer, football and track facilities. Tennis courts, located between the University Center and Margaret Morrison, are lighted for night play. During the school year they are open for use by students, faculty and staff.

These facilities are available to any student, faculty or staff person with a valid Carnegie Mellon ID. For hours, please contact the Athletic Office at (412) 268-1236, or visit our website.

Physical Education

The Department of Physical Education provides an elective program with an emphasis on personal fitness and lifetime recreation, thus preparing students for physical activity after the college years. Most classes are offered on a mini-course system with each class running seven weeks in length.

This program of more than 30 courses is designed for all students, from the beginner to those students who have already developed some skill. Courses include personal fitness, racquetball, tennis, golf, weight training, karate, aerobic fitness, and yoga. Instruction is also provided in several team sports. Carnegie Mellon also provides courses for American Red Cross certification in the four levels of swimming (beginners, intermediate, swimmers, and life guarding), and First Aid and Cardiopulmonary Resuscitation (CPR).

Intramural Sports

For those who seek another level of competition or just like to participate and have fun, the Intramural Program provides recreation and relaxation for all students, faculty and staff, regardless of the degree of their natural athletic skills. The university prides itself on an intramural program which annually involves 6,000 students. Men and women, both graduate and undergraduate, compete in more than 20 different activities. Major sports include flag football, soccer, volleyball, floor hockey, basketball, and softball. A few of our popular tournaments are ultimate frisbee, dodgeball, tennis, and badminton.

Through participation in this program, students are able to keep physically fit, put to good use various learned skills, and develop leadership, team play and sportsmanship. Intramural activities, like all sports endeavors, contribute to physical development, good health, and a sound state of mind, while providing keen competition and team spirit. In addition, intramurals possess an inherent flexibility that allows for a limited commitment of time in light of academic priorities. The intramural program permits students from all departments to meet and socialize on an informal basis.

Fitness and Wellness

The university is well aware that fitness is a vital contributor to an individual's well-being and productivity. For this reason the department is committed to providing the entire campus community with the opportunity and resources to keep fit for the new century.

The Fitness and Wellness program provides educational services, programs, workshops and seminars. Programs include cardio-respiratory fitness, muscular strength, blood pressure and stress reduction. Workshops include the topics of nutrition, weight control, stress management and lower back care and prevention. The Group X program provides over 30 exercise classes per week ranging from yoga and pilates to zumba and spinning.

Faculty

SHANNON AGNEW, Assistant Women's Soccer Coach - Bachelor of Arts, University of Tampa; Carnegie Mellon, 2012-.

SUSAN BASSETT, Director of Athletics - M.S., Indiana University, Carnegie Mellon, 2005-.

GARY ALDRICH, Associate Head Track & Field Coach/Instructor - M.S., Slippery Rock University, Carnegie Mellon, 2006-.

MICHAEL BELMONTE, Assistant Men/Women Tennis - History, Duquesne; Carnegie Mellon, 2010-.

TERRY BODNAR, Assistant Football Coach/Instructor - M.S., Indiana University of PA, Carnegie Mellon, 1984-.

JOSH CENTOR, Assistant Director of Athletics - B.A., Brandeis University, Carnegie Mellon, 2008-.

ALAN DEGENNARO, Strength and Conditioning Coach Carnegie Mellon, 2011-.

DARIO DONATELLI, Head Men's Cross-Country & Track Coach - M.S., Indiana University of PA, Carnegie Mellon, 1984-.

RICHARD ERDELYI, Assistant Football Coach and Head Golf Coach/Instructor - B.A., University of Pittsburgh, Carnegie Mellon, 1987-.

ANDREW GARCIA, Assistant Men's Basketball Coach - History, Tulane University; Carnegie Mellon, 2011-.

SARA GAUNTNER, Assistant Director of Athletics for Instructional Programs & Recreation & Aquatics Director/Instructor - M.S., Duquesne University, Carnegie Mellon, 2005-.

ANDREW GIRARD, Head Men's and Women's Tennis Coach/Instructor - B.S., Michigan Tech University, Carnegie Mellon, 2003-.

SARAH HAYES, Assistant Women's Basketball Coach Carnegie Mellon, 2011-.

JACQUIE HULLAH, Head Women's Basketball Coach Carnegie Mellon, 2011-.

KIM KELLY, Head Women's Volleyball Coach/Instructor - MBA, Mt. St. Mary's University, Carnegie Mellon, 2005-.

MATTHEW KINNEY, Head Swimming and Diving Coach/Instructor - M.S., Western Illinois, Carnegie Mellon, 2007-.

RICHARD LACKNER, Head Football Coach/Instructor - B.A., Carnegie Mellon, Carnegie Mellon, 1979-.

ARRON LUJAN, Head Men's Soccer Coach - M.S., Virginia Commonwealth University, Carnegie Mellon, 2008-.

DONNA MOROSKY, Director of Fitness and Health/Instructor - Post-Graduate Education, University of Pittsburgh; Carnegie Mellon, 1975-.

MICHAEL PIRANIAN, Assistant Men's Soccer Coach/Instructor - B.S., Virginia Polytechnic Institute & State University, Carnegie Mellon, 2008-.

JEFF SIMMONS, Assistant Football Coach/Instructor - B.A., Geneva College; Carnegie Mellon, 2010-.

PATTYE STRAGAR, Operations Manager for Fitness and Aquatics/Instructor - B.S., Northwestern University; Carnegie Mellon, 2003-.

YON STRUBLE, Head Men's Soccer Coach/Instructor - M.S., Georgia State; Carnegie Mellon, 2010-.

TONY WINGEN, Head Men's Basketball Coach/Associate Athletic Director/Instructor - M.Ed., Springfield College; Carnegie Mellon, 1990-.

Reserve Officers' Training Corps (ROTC)

Department of Aerospace Studies (Air Force ROTC)

Steven Hernandez, Lt. Colonel, U.S. Air Force
Office: 2917 Cathedral of Learning, University of Pittsburgh

In the four-year commissioning program, a student takes the general military course (GMC) during the freshman and sophomore years, attends a four-week summer training program, and then takes the professional officer course (POC) in the junior and senior years. In the two-year commissioning program, a student attends a five-week summer training program following his or her junior year and then enters the POC. A student is under no contractual obligation to the Air Force until entering the POC or accepting an Air Force scholarship. In addition to the academic portion of the curriculum, each student attends two hours of leadership lab each week. This lab utilizes a student organization designed for the practice of leadership and management techniques. Two to three and a half year scholarships are available on a competitive basis to qualified students. Many AFROTC scholarships cover a portion of tuition costs, incidentals and lab fees, \$600 for books, plus pay each recipient \$250-\$400 per month.

General Military Course (GMC)

The subject matter for the freshman and sophomore years is developed from an historical perspective and focuses on the scope, structure, and history of military power with emphasis on the development of air power. The freshman courses explore the role of U.S. military forces, and the Air Force in particular, through a study of the total force structure, strategic offensive and defensive forces, general-purpose forces, and support forces.

The sophomore courses include an introduction to the history of air power with emphasis on the development of concepts and doctrine governing the employment of U.S. air power.

Professional Officer Course (POC)

The Professional Officer Course, taken during the cadet's junior and senior years, concentrates on three main themes: the concepts and practices of management, leadership, and national defense policy. During the first term of the junior year, the course concentrates on a study of the management functions: planning, organizing, coordinating, directing and controlling.

Basic and advanced management techniques, as found in the military and industrial environment, are explored. The second term deals with the application of general concepts of leadership to Air Force situations. As a basic study of human behavior, human relationships, and professional ethics, the course emphasizes the similarities between the problems encountered in the military and civilian environment. The first term of the senior course concentrates on selected elements of the U.S. government and national security process engaged in producing national strategy as well as various elements of U.S. military forces, doctrine, and employment capabilities. During the second term, the course concentrates on the strategic options available to the U.S. and on the manner in which policy choices are made. The course also includes a review of the military justice system.

For details about the two programs as well as information on the courses, scholarships and flying programs, interested students are encouraged to contact the Air Force ROTC detachment, or write to the Professor of Aerospace Studies, Air Force ROTC, 2917 Cathedral of Learning, University of Pittsburgh, Pittsburgh, PA 15260.

Department of Military Science (Army ROTC)

Andrew Loeb, Lieutenant Colonel, U.S. Army
Office: Bellefield Hall, Room 409, University of Pittsburgh

The Army Reserve Officers' Training Corps (ROTC) program support-ing Carnegie Mellon University is located at the University of Pitts-burgh. It exists to train the future officer leadership of the United States Army and offers opportunities and challenges that can put college students on the fast track to success in life. ROTC provides a combination of academics and important hands-on training, in addition to physical and mental challenges that will help students succeed in college and beyond. Through the training in ROTC, students will develop the confidence, self-esteem, motivation and leadership skills they will need regardless of their career plans.

The Four-Year Program

The traditional Four-Year program is divided into two parts. The Basic Course is taken in the freshman and sophomore years. There is no commitment for non-scholarship students at this level. Upon successful

completion of the Basic Course, students are eligible for the Advanced Course, taken in the junior and senior years. At the beginning of the Advanced Course, students will decide whether or not they wish to become officers in the Army and enter into a formal contract. During the summer between the junior and senior years, students are required to attend the the Leader Development and Assessment Course (LDAC). Upon successful completion of a University degree and the Army ROTC program, students are commissioned into the United States Army as a Second Lieutenant.

The Two-Year Program

If the first two years of ROTC are not taken, students can attend the Leader's Training Course (LTC) during the summer between the sophomore and junior year. This camp will qualify students to begin the Advanced Course in their junior year or in the first year of a two-year graduate program. Or, if students have served in the active duty military, attended a military academy for one year, participated in JROTC for three years or belong to a Army National Guard or Army Reserve unit, they already qualify for entrance into the Advanced Course.

The Alternative Entry Program

The Alternative Entry Program is designed for academic junior students with no prior qualifying military training but are otherwise qualified. This option allows students to contract into the Advanced Course without receiving placement credit for the basic course. Students accepted into this program must complete the Leader's Training Course and the Leader Development and Assessment Course during the summer months.

Curriculum

Freshman Year		Units
30-101	Introduction to Military Leadership - Fall	5
30-102	Foundations of Leadership- Spring	5
Sophomore Year		Units
30-201	Leadership Dynamics and Application- Fall	5
30-202	Applications in Leadership and Combat Power- Spring	5
Junior Year		Units
30-301	Basic Leader Planning and Combat Operations- Fall	5
30-302	Advanced Leader Planning and Combat Operations- Spring	5
Leadership Development & Assessment Course (six-week required summer camp)		
Senior Year		Units
30-401	Progressive Leadership Theory and Applications- Fall	5
30-402	Transition to the Profession of Arms- Spring	5

Army ROTC Scholarships

Army ROTC offers four, three and two year full scholarships with additional annual allowances of \$900 for books and a monthly stipend. High school, undergraduate and incoming two-year graduate students are eligible to apply. For application and information call ROTC at the University of Pittsburgh at (412) 624-6254/6197.

The Simultaneous Membership Program (SMP)

This program allows students to become members of the Army National Guard or the Army Reserves while enrolled in Army ROTC. Students in the Advanced Course who are SMP are paid for their Guard/Reserve training. The benefit of this program is that students in the Advanced Course are able to act as Army officers in their National Guard or Reserve unit, receiving valuable leadership experience.

Summer Programs

Leadership Development & Assessment Course

This 35-day camp is a requirement for all contracted students. Students attend the summer between their junior and senior year. Students are placed in various leadership positions throughout Camp and their skills and abilities will be tested and evaluated in preparation of a commission in the United States Army. All expenses are paid by the Army. Students are paid while attending.

Leader's Training Course

This 35-day camp is taken as a prerequisite for entry into the Advanced Course if the Basic Course cannot be fulfilled. It is taken the summer before the junior year. All expenses are paid by the Army. Students are paid while attending.

Army Adventure Training

ROTC students may participate in Airborne School, Air Assault School, Northern Warfare School and Mountain Warfare School the summer before the sophomore and junior year. These courses range from two to four weeks and students must arrive in top physical condition. All expenses are paid by the Army.

Extracurricular Activities**Rangers**

Army ROTC students are eligible to participate in the Cadet Ranger Club.

The Club conducts physically and mentally challenging extracurricular training to promote fitness, teamwork, self-confidence and fellowship. Training includes physical fitness, rappelling, rope bridging, tactics, hiking, climbing, weapons training and orienteering.

Scabbard & Blade

National Honor Society consisting of cadets/midshipmen from Army, Air Force and Naval ROTC.

Rho Tau Chi

Military fraternity established for the members of the various branches of ROTC. Purpose is to draw together cadets to increase communication and feelings of goodwill between the Cadet Corps and the community. Cadets participate in a variety of community service projects.

Color Guard

Dedicated group of Army ROTC cadets who train and perform to present the American flag and Army colors at football and basketball games and various community events.

Department of Naval Science (Naval ROTC)

Thomas M. Calabrese, Captain, U.S. Navy
Office: 4615 Forbes Avenue

The Department of Naval Science was established 16 December 1987. Its mission is to prepare young men and women mentally, morally, and physically, and to instill in them the highest qualities of duty, honor, and loyalty, in preparation for leadership positions in the naval service.

Carnegie Mellon's Naval Reserve Officers Training Corps (NROTC) is designed for young men and women who are seeking a challenging academic experience and who desire to serve their country as officers in the Navy or Marine Corps after graduation.

NROTC midshipmen lead the same campus life as other Carnegie Mellon students. They make their own arrangements for room and board, choose a preferred area of study and participate in extracurricular activities. Midshipmen wear civilian clothes to classes but wear uniforms one day of the week. NROTC students are active in all facets of university life; many are in positions of leadership in student government, on varsity and intramural sports teams, in campus clubs, and other student organizations. The NROTC program seeks students who are bright, ambitious, enthusiastic leaders whose lives are enriched by their education at Carnegie Mellon and by their involvement in NROTC.

Four-Year Scholarship Program

The four-year scholarship program provides full tuition and university fees, \$750 for textbooks per year, uniforms, and a \$250 per month tax-free subsistence allowance to students during their freshman year. This stipend then increases to \$300 during their sophomore year, \$350 for their junior year and \$400 for their senior year. Midshipmen must complete the university-approved curriculum of their choice, including courses in calculus and calculus-based physics (Navy Option Only), and specified courses in naval science subjects. Paid summer training periods are also provided. Scholarships are awarded on the basis of a nationwide competition before the start of the freshman year. Midshipmen commissioned through the scholarship programs become officers in the Navy or Marine Corps and incur a four-year active duty obligation in a selected area of the naval service.

Tweedale Scholarship Program

This scholarship program provides the same benefits as the four-year program, but is targeted toward currently enrolled students who have completed at least one, but not more than four semesters, and who are pursuing technical majors. This program allows a highly-qualified engineering, physics, chemistry, or mathematics student who has never applied for a NROTC scholarship in the past to be considered for this scholarship. Solid academic standing within his or her field of study is required, including a ranking within the top half of students pursuing his or her chosen course of study. If nominated by the Professor of Naval Science for this scholarship, the student will generally receive a scholarship decision within 5 working days from submission. Midshipmen commissioned through

the scholarship programs become officers and incur a four-year active duty obligation in a selected area of the naval service.

College (Non-Scholarship) Programs in NROTC

Qualified students may participate in NROTC as college program (non-scholarship) midshipmen and earn commissions in the Navy or Marine Corps Reserve upon graduation. The active duty obligation for this program is three years. Students receive all naval science textbooks and uniforms. Additionally, if awarded advanced standing during their junior and senior years, they receive a tax-free subsistence monthly allowance of \$350 and \$400 respectively. A paid summer training period is provided between the junior and senior year. College program students may compete for three- and two-year scholarships described in the following paragraph.

College Program Three- and Two-Year Scholarships

Three-year scholarships are available on a competitive basis to those qualifying college program (non-scholarship) NROTC students who have demonstrated leadership and academic excellence during their freshman or sophomore year and are nominated for the scholarship by the Professor of Naval Science. Scholarship benefits are identical to those provided by the four-year scholarship program. Active duty obligation is four years upon commissioning in a selected area of the naval service.

Two-Year National Scholarship Program

Sophomores who have not participated in the NROTC program may apply for a nationally competitive two-year scholarship. The two-year scholarship program provides the same benefits as the four-year program for a period of 20 months. Students must apply for this program no later than February of their sophomore year. Students selected for this program attend the Naval Science Institute during the summer before their junior year to complete required naval science course material. A paid summer training period is provided between the junior and senior years. Commissionees incur a four-year active duty obligation upon graduation in a selected area of the naval service.

Curriculum

The sequence of naval science courses is the same for all officer candidates for the first three semesters. Midshipmen accepted into the Marine Corps option program will have curriculum variations starting with their third year.

Additionally, some candidates may be required to complete courses in American military affairs, national security policy, English, mathematics, and/or the physical sciences. Descriptions of the course requirements for each candidate classification (scholarship/college program) may be obtained from the Department of Naval Science office.

All scholarship and college program students are required to attend a weekly 1.5 hour Naval Laboratory (32-100) where professional orientation, military drill, physical fitness, and leadership are emphasized. Guest speakers from the Fleet are frequent participants in these laboratories. Naval Science courses are open to all students. Since these are required courses for NROTC students, they will be given priority in enrollment. Remaining spaces will be filled through the normal university registration process.

(Naval Science Courses)Naval Professional Academic Courses

Freshman Year		Units
32-100	Naval Laboratory	3
32-101	Introduction to Naval Science	6
32-102	Seapower and Maritime Affairs	6
Sophomore Year		Units
32-200	Naval Laboratory	3
32-201	Leadership & Management	9
32-212	Navigation *	9
Junior Year		Units
32-300	Naval Laboratory	3
32-310	Evolution Of Warfare **	9
32-311	Naval Ship Systems I-Engineering *	9
32-312	Naval Ship Systems II-Weapons *	9
Senior Year		Units
32-400	Naval Laboratory	3
32-402	Leadership and Ethics	9
32-410	Amphibious Warfare **	9
32-411	Naval Operations and Seamanship *	9

Footnotes:

* Required of students in the Navy Option

** Required of students in the Marine Option

All other courses are required of all students in the program.

Naval ROTC Faculty

JEFF CORAN, Captain, USN - M.S., Rensselaer Polytechnic Institute; Carnegie Mellon, 2014-

Intercollege Programs

Carnegie Mellon University offers several degree programs and courses of study which are coordinated by multiple colleges, reflecting the interdisciplinary nature of the university. These are detailed below.

BXA Intercollege Degree Programs

The BXA Intercollege Degree Programs enable students the freedom to individualize their educational experience by promoting integration, balance and innovation. There are three degree programs from which to choose:

- Bachelor of Humanities and Arts
- Bachelor of Science and Arts
- Bachelor of Computer Science and Arts

For detailed information on the BXA Intercollege Degree Programs, go to BXA Intercollege Degree Programs (p. 88).

Bachelor of Science in Computational Biology

Computational Biology is concerned with solving biological and biomedical problems using mathematical and computational methods. It is recognized as an essential element in modern biological and biomedical research. There have been fundamental changes in biology and medicine over the past decade due to spectacular advances in biomedical imaging, genomics, and proteomics. The nature of these changes demands the application of novel theories and advanced computational tools to decipher the implications of these data, and to devise methods of controlling or modifying biological function. Consequently, Computational Biologists must be well trained and grounded in biology, mathematics, and computer science.

The School of Computer Science and Mellon College of Science have joined forces to establish an exciting interdisciplinary program leading to a B.S. in Computational Biology. The goal of this degree program is to provide an intensive interdisciplinary education to enable outstanding students to become leaders in identifying and solving tomorrow's biological problems using computational methods. The program's curriculum is truly interdisciplinary and is designed for students interested in the intersection of Biology and Computer Science.

Applications to the program are invited from current sophomores. Applicants must have completed, or be currently enrolled in 03-231/232 and 15-210 or 15-251. Applicants must submit an essay describing their interest in the program. Completed applications should be submitted to Dr. Maggie Braun at mabraun@andrew.cmu.edu in Doherty Hall 1320, Dr. Karen Thickman at krthickman@cmu.edu in Gates-Hillman Center 7403, or Dr. Tom Cortina at tcortina@cs.cmu.edu in Gates-Hillman Center 4117 no later than one week after midsemester grades are released in a given semester.

Degree Requirements

47 units Math/Stats Core

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
21-xxx	Math Elective (21-241, 21-260, 21-341)	9
36-xxx	Statistics Elective (36-217, 36-225, 36-247, 36-625)	9

41 units General Science Core

09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
33-111	Physics I for Science Students	12

51 units Biological Sciences Core

03-121	Modern Biology	9
03-231	Biochemistry I	9
or 03-232	Biochemistry I	
03-240	Cell Biology	9
03-330	Genetics	9
03-342	Introduction to Biological Laboratory Practices *	1

03-343	Experimental Techniques in Molecular Biology *	12
03-201	Undergraduate Colloquium for Sophomores	1
or 15-128	Freshman Immigration Course	
03-411	Topics in Research	1

* these two courses are co-requisites and must be taken together.

56 units Computer Science Core

15-122	Principles of Imperative Computation	10
15-150	Principles of Functional Programming	10
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-251	Great Theoretical Ideas in Computer Science	12
15-451	Algorithm Design and Analysis	12

45-54 units Major Electives

03-511	Computational Molecular Biology and Genomics	9
03-xxx, 05-xxx, or 02-xxx	Computational Biology Electives	18-24
03-3xx	Advanced Biology Elective	9
15-xxx	Advanced Computer Science Elective (15-211 or higher)	9

75 units General Education

99-10x	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
	Elective Cognition, Choice and Behavior	9
	Elective Economics, Political and Social Institutions	9
	Elective Cultural Analysis	9
	Non-technical Elective	9
	Non-technical Elective	9
	Non-technical Elective	9
	Non-technical Elective	9

40-49 units Free Electives

360 Minimum number of units required for degree:

Bachelor of Science in Computational Finance

The Mellon College of Science, the Heinz College of Public Policy and Management and the Tepper School of Business jointly offer a degree uniquely designed to meet the quantitative needs of the finance industry. Modeled after the highly successful Carnegie Mellon Master of Science in Computational Finance, this degree allows students to develop a deep knowledge of mathematics, probability, statistics, and the applications of these disciplines to finance. Students who complete this degree may directly enter the finance industry, enter other industries where an applied mathematics training is appropriate, or pursue advanced degrees in economics, finance or the mathematical sciences. Students entering the work force upon completion of this degree may wish to later complement their undergraduate degree with a Master's degree in Business Administration or other professional degree. Students who might eventually pursue doctoral degrees in economics, finance, statistics or mathematics should seek advising on how to use their electives in order to prepare for graduate work in their chosen disciplines. Students apply for admission to the B.S. program in Computational Finance in the second semester of the sophomore year. Later application is also possible.

The Bachelor of Science in Computational Finance is an Intercollegiate Program. Students who pursue Computational Finance as their primary major may elect to have either the Mellon College of Science (MCS) or the Tepper School of Business (Tepper) as their home college. The coursework required for the major is the same in either case, with one minor exception outlined below. The general education requirements for the degree depend on the student's home college. MCS students must complete the same Humanities, Social Sciences, and Fine Arts requirements as other MCS students. In addition, MCS students are required to take two science courses, one fewer than other MCS majors. Tepper students must complete the Breadth Requirements of the Undergraduate Business Administration Program. Additionally, they must take several courses from the Functional Business Core of that program.

Majors in Computational Finance can tailor their degree program by selecting Depth Electives aligned with their interests and ambitions. MCS students are required to take three depth electives. Tepper students must take two depth electives and 70-391 Finance (MCS students may select 70-391 as one of their three depth electives).

MCS Science Requirements

Students intending to apply to the B.S. program in Computational Finance should take two semesters of calculus, 21-120 Differential and Integral Calculus and 21-122 Integration and Approximation, and 15-110 Principles of Computing.

In addition, in the freshman year students should complete two of the following three courses:

03-121	Modern Biology	9
09-105	Introduction to Modern Chemistry I	10
33-111	Physics I for Science Students	12

MCS Humanities, Social Sciences & Fine Arts Requirements

Candidates for the B. S. in Computational Finance must complete 72 units offered by Dietrich College of Humanities and Social Science and/or the College of Fine Arts. Of these 72 units, 36 are specified by the detailed curriculum in below. These are:

76-101	Interpretation and Argument	9
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9

Two more nine unit courses must be in specific categories as listed in the section on general requirements for a Bachelor's degree in the Mellon College of Science. One in Category 1: Cognition, Choice and Behavior, and one in Category 3: Cultural Analysis. The remaining 18 units may be filled by courses from any of the departments in DC, CFA or Tepper, subject to the list of exclusions and additions maintained by MCS.

Tepper Functional Business Core

The Functional Business Core of the Undergraduate Business Administration Program includes 70-122 Introduction to Accounting, which is required by all Computational Finance majors. It also includes 70-391, which Tepper students majoring in Computational Finance must select as one of their Depth Electives. In addition, Tepper students pursuing the B.S. in Computational Finance must complete six other courses from the Functional Business Core.

These courses are:

70-100	Global Business	9
70-311	Organizational Behavior	9
70-332	Business, Society and Ethics	9
70-371	Operations Management	9
70-381	Marketing I	9
70-401	Management Game	12

Tepper Breadth Requirements

Candidates for the B.S. in Computational Finance must complete the breadth requirements outlined in the section describing the Undergraduate Business Administration Program.

Depth Electives

The detailed curricula below include three or four depth electives. These may be chosen from among the following:

21-355	Principles of Real Analysis I	9
21-365	Projects in Applied Mathematics	9
21-372	Partial Differential Equations and Fourier Analysis	9
36-401	Modern Regression	9
36-402	Advanced Methods for Data Analysis	9
70-391	Finance	9
70-398	International Finance	9
70-492	Investment Analysis	9
70-495	Corporate Finance	9
70-497	Derivative Securities	9
73-372	International Money and Finance	9

MCS Detailed Curriculum

What follows is the detailed curriculum for the degree Bachelor of Science in Computational Finance in the Mellon College of Science. The courses listed are required. The semesters in which the courses are to be taken are suggested.

Freshman Year

Fall		Units
15-110	Principles of Computing	10
21-120	Differential and Integral Calculus	10
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
xx-xxx	Science Requirement	9-12
		32

Spring		Units
15-112	Fundamentals of Programming and Computer Science	12
21-122	Integration and Approximation	10
70-122	Introduction to Accounting	9
xx-xxx	Science Requirement (9-12 units)	12
xx-xxx	Elective	9
		52

Sophomore Year

Fall		Units
21-127	Concepts of Mathematics	10
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
73-100	Principles of Economics	9
xx-xxx	Humanities, Social Science or Fine Arts Elective	9
		46

Spring		Units
21-241	Matrices and Linear Transformations	10
21-270	Introduction to Mathematical Finance	9
21-369	Numerical Methods	9
73-230	Intermediate Microeconomics	9
xx-xxx	Elective	9
		46

Junior Year

Fall		Units
15-122	Principles of Imperative Computation	10
21-325	Probability	9
21-370	Discrete Time Finance	9
73-240	Intermediate Macroeconomics	9
xx-xxx	Elective	9
		46

Spring		Units
21-420	Continuous-Time Finance	9
36-226	Introduction to Statistical Inference	9
36-410	Introduction to Probability Modeling	9
xx-xxx	Humanities, Social Science or Fine Arts Elective	9
xx-xxx	Depth Elective	9
		45

Senior Year

Fall		Units
45-925	Studies in Financial Engineering	6
90-718	Strategic Presentation Skills	6
94-700	Organizational Design & Implementation	6
xx-xxx	Depth Elective	9
xx-xxx	Humanities, Social Science or Fine Arts	9
xx-xxx	Elective	9
		45

Spring		Units
94-702	Professional Writing	6
or 94-701	Business English	
xx-xxx	Depth Elective	9
xx-xxx	Humanities, Social Science or Fine Arts Elective	9
xx-xxx	Elective	9
xx-xxx	Elective	9
xx-xxx	Elective	0-6
		42

Tepper Detailed Curriculum

What follows is the detailed curriculum for the degree Bachelor of Science in Computational Finance in the Tepper School of Business. The courses listed are required. The semesters in which the courses are to be taken are suggested.

Freshman Year

Fall		Units
15-110	Principles of Computing	10
21-120	Differential and Integral Calculus	10
or 21-122	Integration and Approximation	
70-100	Global Business	9
73-100	Principles of Economics	9
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
		50

Spring		Units
15-112	Fundamentals of Programming and Computer Science	12
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
73-230	Intermediate Microeconomics	9
xx-xxx	Breadth Course	9
xx-xxx	Breadth Course	9
		59

Sophomore Year

Fall		Units
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
21-325	Probability	9
70-122	Introduction to Accounting	9
73-240	Intermediate Macroeconomics	9
		45

Spring		Units
21-241	Matrices and Linear Transformations	10
21-270	Introduction to Mathematical Finance	9
36-226	Introduction to Statistical Inference	9
70-311	Organizational Behavior	9
70-381	Marketing I	9
		46

Junior Year

Fall		Units
15-122	Principles of Imperative Computation	10
21-370	Discrete Time Finance	9
70-391	Finance	9
xx-xxx	Breadth Course	9
xx-xxx	Elective	9
		46

Spring		Units
21-369	Numerical Methods	9
21-420	Continuous-Time Finance	9
36-410	Introduction to Probability Modeling	9
70-371	Operations Management	9

xx-xxx	Breadth Course	9
		45

Senior Year

Fall		Units
45-925	Studies in Financial Engineering	6
70-332	Business, Society and Ethics	9
70-401	Management Game	12
xx-xxx	Breadth Course	9
xx-xxx	Depth Elective	9
		45

Spring		Units
90-718	Strategic Presentation Skills	6
94-702	Professional Writing	6
or 94-701	Business English	
xx-xxx	Depth Elective	9
xx-xxx	Breadth Course	9
xx-xxx	Breadth Course	9
xx-xxx	Elective	9
		48

Minor in Computational Finance

Students do not need to apply for the minor in Computational Finance, however in order to declare the minor in Computational Finance, a student must satisfy one of the following two requirements:

1. Completion of 21-270 Introduction to Mathematical Finance with a grade of A and an overall QPA of at least 3.20.
- or
2. Completion of 21-270 Introduction to Mathematical Finance and 21-370 Discrete Time Finance with an average grade of B and an overall QPA of at least 3.00.

When a student has met the necessary requirements, he or she may declare the minor by contacting the Associate Director of the Undergraduate Computational Finance program.

21-241	Matrices and Linear Transformations	9-10
or 21-242	Matrix Theory	
or 21-341	Linear Algebra	
21-259	Calculus in Three Dimensions	9
or 21-256	Multivariate Analysis	
21-260	Differential Equations	9
21-270	Introduction to Mathematical Finance	9
21-370	Discrete Time Finance *	9
21-420	Continuous-Time Finance **	9

To avoid excessive double counting, Computational Finance minors may not count 21-270 Introduction to Mathematical Finance, 21-370 Discrete Time Finance or 21-420 Continuous-Time Finance toward any other requirement.

*The prerequisites for 21-370 are 21-270 and either 21-256 or 21-259, and the co-requisite is 70-207, 21-325, 36-225 or 36-217. Note that 70-207 is not accepted as a prerequisite for 21-420.

** The prerequisites for 21-420 are 21-260, 21-370 and one of the following three calculus based probability courses: 21-325, 36-225 or 36-217. Note that 70-207 is not a sufficient preparation in probability. Also note that 21-122 is a prerequisite for 21-260 and that 21-127 is a prerequisite for 21-341 and is recommended for 21-241.

Students minoring in Computational Finance are strongly encouraged to take one or two economics course, e.g., 73-100, 73-230, or 73-240.

Game Design Minor - IDEATe

The Game Design minor is offered by the Entertainment Technology Center as part of the Integrative Design, Arts and Technology (IDEATe) network. IDEATe offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students will engage in active "learning by doing" in state-of-the-art maker spaces. The program addresses current and emerging real-world

challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDeATe undergraduate curriculum consists of eight interrelated concentration areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and arts: Game Design, Animation & Special Effects, Media Design, Learning Media, Sound Design, Innovation and Entrepreneurship, Intelligent Environments, and Physical Computing. For more information about the IDeATe network, please visit <http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#ideate>

In the Game Design minor, students are able to enhance their knowledge of key component areas of games such as dramatic narrative and character development, programming and engine development, game assessment and redesign. They will have the opportunity to create games for varied platforms from mobile devices to home entertainment systems and theme parks.

Curriculum

Required Courses

One Portal Course

15-104 Introduction to Computing for Creative Practice for students in Dietrich College, the College of Fine Arts, and the Tepper School of Business. (DC, CFA, and TSB students may take 15-112 Fundamentals of Programming and Computer Science as a substitute for 15-104.)

62-150 Introduction to Media Synthesis and Analysis for students in the College of Engineering, Mellon College of Science, and School of Computer Science.

Four Collaborative or Supportive Courses

16-465 Game Engine Programming
53-471 Game Design, Prototyping, and Production
53-230 Programming for Game Designers
53-451 Research Issues in Game Development
05-418 Design of Educational Games
15-466 Computer Game Programming
53-371 Role Playing Games Writing Workshop
60-419 Experimental Game Design

Electives

Students may take a collaborative or supportive course from one of the other IDeATe areas as one of their four collaborative or supportive courses toward the Game Design minor.

Double-Counting Restriction

Students may double-count two of their Game Design minor courses for other requirements.

Minor in Health Care Policy and Management

Sponsored by:

H. John Heinz III College
Dietrich College of Humanities and Social Sciences
Mellon College of Science

Faculty Advisors:

Jason D'Antonio, Mellon College of Science
James F. Jordan, H. John Heinz III College

The face of health care is changing. The practice of medicine is being fundamentally altered by the forces of change in public policy, health care organizations and in the industry as a whole. The role of individual professionals in this industry is changing as rapidly as the industry itself. Traditional career paths have disappeared overnight to be replaced by new opportunities that require new skills. New organizations are placing new demands on their professional and medical staffs. The criteria of efficiency and financial stability are entering the domains of diagnosis and treatment.

This minor is designed to provide students considering a career in the health professions with an understanding of how these changes are likely to affect their careers. Students will become familiar with the critical policy and management issues and will begin to learn to operate effectively in the emerging health care environment. The curriculum combines economic, organizational, managerial, historical and psychological perspectives on these issues to provide a foundation for a deepened understanding of the changing structure of health care organizations and policy.

Curriculum

60 units minimum

Seven courses (a minimum of 60 units) are required to complete this minor. Entry into the minor requires completion of 73-100 Principles of Economics or 88-220 Policy Analysis I or the equivalent by approval.

Required Courses

39 units

Students are required to take the following courses.

79-330	Medicine and Society	9
90-836	Health Systems	6
90-861	Health Policy	6
94-705	Health Economics	12

Elective Courses

27 units

Complete a minimum of 27 units.

Heinz College Courses

90-708	Healthcare Ethics	6
90-721	Healthcare Management	6
90-818	Health Care Quality & Performance Improvement	6
90-830	Introduction to Financial Management of Health Care	6
90-831	Advanced Financial Management of Health Care	6
90-832	Health Law	6
90-863	Health Policy II	6
94-706	Healthcare Information Systems	12

Humanities and Social Sciences Courses (9 units each)

76-494	Healthcare Communications	9
79-383	Epidemics, Disease, and Public Health	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
85-241	Social Psychology	9
85-442	Health Psychology	9
85-446	Psychology of Gender	9

Please note that some of these courses have prerequisites that will not count toward the completion of the requirements for this minor.

Additional Major in Human-Computer Interaction

Robert Kraut, Undergraduate Advisor

Office: Newell Simon Hall (NSH) 3515

For up to date information, see: <http://www.hcii.cmu.edu/applying-undergraduate-major>

Overview

Human-Computer Interaction (HCI) is a fast growing field devoted to the design, implementation, and evaluation of interactive computer-based technology. Examples of HCI products include intelligent computer tutors, wearable computers, social networking sites, and internet connected personal digital assistants (PDAs). Constructing an HCI product is a cyclic, iterative process that has at least three stages: Design, Implementation, and Evaluation.

The Design stage involves principles of design and human behavior, the Implementation stage principles of computer science, and the Evaluation stage empirical research methods common to several disciplines. There are thus four topical areas to cover in this major: Human Behavior, Design, Implementation, and Evaluation. In slightly more detail, the major involves the following sorts of knowledge and skill:

Design

- Eliciting from the client, formulating, and articulating functional specifications
- Knowing how human factors and cognitive models should inform design
- Knowing the principles of, and having experience with, communication design
- Understanding how implementation constraints should inform design
- Incorporating evaluation results into iterated designs

Implementation Programming Skills

- Standard programming languages - e.g., C++, Java

- Rapid prototyping skill (e.g., Visual Basic, Flash)
- Computational literacy, i.e., knowledge sufficient for effective communication and decision making about:
 - interface construction tools and languages
 - multimedia authoring tools
 - data structures and algorithms
 - Operating systems, platforms, etc.

Evaluation

- Experimental design
- Focus Groups
- Surveys
- Usability Testing (Cognitive walkthroughs, user models, heuristic evaluation, GOMS)
- Statistical Analysis

There are over 45 courses relevant to these areas that are now offered by eight different departments in four different colleges at Carnegie Mellon (the School of Computer Science, the College of Humanities and Social Sciences, and the College of Fine Arts, and the Tepper School of Business).

Curriculum

Required Courses

Cognitive Psychology:		Units
85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	
Communication Design Fundamentals:		
51-261	Communication Design Fundamentals: Design for Interactions for Communications ^b	9
Statistics (one of the following):		
36-201	Statistical Reasoning and Practice	9
36-207	Probability and Statistics for Business Applications	9
36-220	Engineering Statistics and Quality Control	9
36-225-36-226	Introduction to Probability Theory - Introduction to Statistical Inference	18
36-247	Statistics for Lab Sciences	9
70-207	Probability and Statistics for Business Applications	9
Introduction to Programming:		
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
or 15-121	Introduction to Data Structures	
Basic Interaction Design:		
51-421	Basic Interaction Design ^c	9
or 51-422	Interaction Design Studio	
Evaluation (one of the following):		
36-202	Statistical Methods ^a	9
36-208	Regression Analysis	9
36-303	Sampling, Survey and Society	9
36-309	Experimental Design for Behavioral and Social Sciences	9
85-310	Research Methods in Cognitive Psychology	9
85-340	Research Methods in Social Psychology	9
88-251	Empirical Research Methods	9
70-208	Regression Analysis	9
70-481	Marketing Research	9
Human-Computer Interaction Methods		
05-410	User-Centered Research and Evaluation	12
Interface Programming:		
05-430	Programming Usable Interfaces	15
or 05-431	Software Structures for User Interfaces	
05-433	Programming Usable Interfaces OR Software Structures for Usable Interfaces	6
Project Course:		
05-571	Undergraduate Project in HCI	12

Notes

^a The evaluation and statistics courses are required so that majors will be able to understand and conduct empirical research in HCI. Therefore a mathematically-oriented probability course, such as 36-217 Probability Theory and Random Processes does not fulfill either requirement.

^b Design majors do not need to take 51-261 Communication Design Fundamentals: Design for Interactions for Communications as a prerequisite, since they learn similar material in other courses for their major. HCI undergraduates taking Communication Design Fundamentals must go to the School of Design office, MM 110, to register for the course on their assigned day. ID will be required.

^c HCI double majors are guaranteed a place in 51-422 Interaction Design Studio, offered every spring by the School of Design for HCI double majors. Students intending to take 51-422 must visit the School of Design office in MM 110 during registration week to fill out an instructor-permission request form. The content of this course is comparable to 51-421 (Fall).

Electives (18 Units)

Electives are intended to provide HCI double majors advanced concepts and skills relevant to HCI or breadth of experience not available from their primary major. Given these goals, most electives will be 300-level courses or higher. Courses at the 100-level and 200-level in one's primary major will not count as electives, although the same course taken by a non-major may count (approval is still required).

Students can take electives in the HCII or courses relevant to HCI from many other departments on campus. All electives are approved on a case-by-case basis. Undergraduate majors request approval of an elective using The HCI Institute's EASy requirements' management system (<http://easy.hcii.cs.cmu.edu/easy>). The director of the undergraduate program will approve the request, ask for more information or reject it. The EASy system then keeps a record of the electives approved for a particular student.

The following courses have been approved as electives in the past, organized by the offering department:

Human-Computer Interaction		Units
05-320	Social Web	12
05-395	Applications of Cognitive Science	9
05-413	Human Factors	9
05-431	Software Structures for User Interfaces	15
05-540	Rapid Prototyping of Computer Systems	12
05-589	Independent Study in HCI-UG	Var.
Machine Learning		
10-601	Introduction to Machine Learning	12
Computer Science		
15-390	Entrepreneurship for Computer Science	9
15-421	Information Security and Privacy	12
15-437	Web Application Development	12
15-462	Computer Graphics	12
15-466	Computer Game Programming	12
Statistics		
36-201	Statistical Reasoning and Practice	9
36-309	Experimental Design for Behavioral and Social Sciences	9
Architecture		
48-739	Making Things Interactive (Graduate)	10
Design		
51-241	How People Work	9
51-274	Design and Social Change	9
51-324	Basic 3D Prototyping	4.5
51-383	Topics: Conceptual Models	9
51-385	Design for Service	9
51-424	Web Portfolio	4.5
Art		
60-418	ETB Studio: The Interactive Image	10
Business Administration		
70-414	Entrepreneurship for Engineers	9

Double Counting

All prerequisites can be double counted with any requirements in your primary major. At most three non-prerequisite courses can be double counted with the primary major and the HCI second major. For example, if you are majoring in Cognitive Psychology, then you might want to take 85-211 (Intro to Cognitive Psychology) as one of your three double counts. If more than three of the requirements are already in your primary major, then you must add electives until you have eight HCI courses not required as part of your primary major.

Accelerated Master's Programs

The HCI Institute currently offers a three semester (12-month), 15 course Masters in HCI. Undergraduates who have taken the core courses, and an elective on the 400 level or above will be considered eligible for the Accelerated Masters program. These students, which include all undergraduate HCI majors, can apply for the Accelerated Masters program by November 1st of their Senior year, and can begin the Masters program in the Spring of their Senior year. They can finish the Masters degree after the Summer and Fall.

Admission to the Major

The HCI undergraduate major is currently available only as a second major. Because space is limited in the major's required courses, enrollment in the HCI undergraduate major is currently limited to 25 students in each graduating class. 6 with a primary major in Design, 6 in H&SS, 6 in SCS, and 7 anywhere. Applications are processed once a year, during Spring Break. For more detail, see the website: <http://hcii.cs.cmu.edu/academics/hci-undergraduate/major/applying>.

B.S. in Mathematical and Statistical Sciences

This degree program is administered under the joint Science & Humanities Scholars Program between the Mellon College of Science and the College of Humanities & Social Sciences. To qualify, a student must be acceptable for admission to both colleges.

85 Units Mathematical Sciences:

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
21-241	Matrices and Linear Transformations	10
21-259	Calculus in Three Dimensions	9
21-201	Undergraduate Colloquium	1
21-292	Operations Research I	9
21-355	Principles of Real Analysis I	9
or		
21-369	Numerical Methods	9
21-xxx	Mathematical Science Elective	
21-xxx	Mathematical Science Elective	

36 Units Probability and Statistics:

21-325	Probability	9
or 36-225	Introduction to Probability Theory	
Note: 21-325 Probability is preferred.		
36-226	Introduction to Statistical Inference	9
36-410	Introduction to Probability Modeling	9
36-461	Special Topics: Statistical Methods in Epidemiology	9

27 Units Data Analysis:

36-247	Statistics for Lab Sciences	9
36-309	Experimental Design for Behavioral and Social Sciences	9
or		
36-303	Sampling, Survey and Society	9
36-401	Modern Regression	9

18 Units Statistics and Data Analysis Electives:

Complete two courses from the following:

21-393	Operations Research II	9
36-402	Advanced Methods for Data Analysis	9
36-462	Special Topics: Data Mining	9

In consultation with his/her advisor, the student may also arrange to take Statistics graduate courses (36-7xx) to satisfy part of this requirement.

Joint MCS/H&SS Core other than Mathematical Science 103-107 Units or Statistics courses:

Free Electives:
Enough to reach 360 Units

Sample Course Sequence: Math & Statistical Sciences**Freshman Year**

Fall		
21-120	Differential and Integral Calculus	10
21-127	Concepts of Mathematics	10
76-101	Interpretation and Argument	9
33-111	Physics I for Science Students	12
99-10x	Computing @ Carnegie Mellon	
Spring		
21-122	Integration and Approximation	10
36-247	Statistics for Lab Sciences	9
79-104	Global Histories	9
xx-xxx	Science	
xx-xxx	Freshman Seminar	

Sophomore Year

Fall		
21-201	Undergraduate Colloquium	1
21-241	Matrices and Linear Transformations	10
36-309	Experimental Design for Behavioral and Social Sciences	9
xx-xxx	Economic, Political and Social Institutions	
xx-xxx	Science	
xx-xxx	Elective	
Spring		
21-201	Undergraduate Colloquium	1
21-259	Calculus in Three Dimensions	9
21-292	Operations Research I	9
xx-xxx	Cultural Analysis	
xx-xxx	Electives	

Junior Year

Fall		
21-355	Principles of Real Analysis I	9
21-325	Probability	9
xx-xxx	Cognition, Choice and Behavior	
xx-xxx	Electives	
Spring		
21-xxx	Mathematical Science Elective	
36-226	Introduction to Statistical Inference	9
36-410	Introduction to Probability Modeling	9
xx-xxx	Creative Production & Reflection	
xx-xxx	Electives	

Senior Year

Fall		
21-393	Operations Research II	9
36-401	Modern Regression	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
xx-xxx	Electives	
Spring		
21-xxx	Mathematical Science Elective	

36-402	Advanced Methods for Data Analysis	9
36-xxx	Senior Research Elective	
xx-xxx	Electives	

Bachelor of Science in Music and Technology

The Bachelor of Science in Music and Technology is offered jointly by the School of Music, the School of Computer Science (SCS), and the Carnegie Institute of Technology (CIT).

This program consists of a set of courses that span both music and technology, as well as a capstone composition/design/performance project. Courses in all three areas of study are stipulated in the music and technology undergraduate curriculum and provide for students coming from any of the three areas. In other words, regardless of a student's entry point — an interest in computer science, electrical engineering, or music — the coursework prescribed will allow the student to gain the requisite knowledge and experience in all three areas. Students will work closely with advisors and will be guided in both course selection and capstone projects.

General Requirements 85 units

Seminar

57-570	Music and Technology Seminar (8 semesters for a total of 8 units)	8
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University

99-10x	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
79-104	Global Histories	9

Humanities

xx-xxx	Cognition, Choice and Behavior course	9
xx-xxx	English, History, Modern Languages, Philosophy, or Psychology course	9

Mathematics

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10

Science

33-114	Physics of Musical Sound	9
33-106	Physics I for Engineering Students	12

Electives 33 units

Music Core 87 units

57-152	Harmony I	9
57-153	Harmony II	9
57-408	Form and Analysis	6
57-151	Counterpoint in Theory and Application	6
57-258	20th-21st Century Techniques	6
57-257	Orchestration I	6
57-xxx	Music Support Course	6
57-189	Introduction to Repertoire and Listening for Musicians	3
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-181	Solfege I	3
57-182	Solfege II	3
57-183	Solfege III	3
57-184	Solfege IV	3
57-161	Eurhythmics I	3
57-162	Eurhythmics II	3
57-173	Survey of Western Music History	9

Music and Technology Core 120 units

15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10

15-322	Introduction to Computer Music	9
18-100	Introduction to Electrical and Computer Engineering	12
18-202	Mathematical Foundations of Electrical Engineering	12
18-290	Signals and Systems	12
57-101	Introduction to Music Technology	6
57-347	Electronic and Computer Music	6
57-337	Sound Recording	6
57-338	Sound Editing and Mastering	6
57-438	Multitrack Recording	9
57-571	Music and Technology Project	12
57-572	Music and Technology Project	12

Concentration

Students complete either the Music Concentration or the Technical Concentration:

Music Concentration 60 units

57-5xx	Studio (4 semesters)	36
57-4xx	Major Ensemble (4 semesters)	24

Technical Concentration 57 or 55 units

21-127	Concepts of Mathematics	10
15/18-213	Introduction to Computer Systems	12

AND EITHER:

18-220	Electronic Devices and Analog Circuits	12
18-240	Structure and Design of Digital Systems	12
15-2xx/18-3xx	Electives in ECE or CS	12

or above

OR:

15-128	Freshman Immigration Course	1
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-323	Computer Music Systems and Information Processing	9

15-2xx/18-3xx	Electives in ECE or CS	12
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or above

Total number of units required for major 380

Bachelor of Science in Neuroscience

Aaron P. Mitchell, Interim Department Head, Biological Sciences

Michael Tarr, Department Head, Psychology

www.cmu.edu/neuro

Neuroscience is an interdisciplinary field in which scientists from many backgrounds apply the tools of biology, cognitive science, psychology, chemistry, mathematics, statistics, computer science, and engineering to develop a comprehensive understanding of brain function at the level of molecules, neurons, brain circuits, cognitive brain modules, and behavior. Research in neuroscience across these disciplines has grown substantially in the past two decades, and a solid understanding of the physiological basis of many aspects of brain function both in health and disease has come along with this growth in research. Along with this comes an increasing need for students to begin careers in neuroscience and to be prepared to work on the problems in neuroscience and to bring new answers to the public and to patients. In order to be successful in developing new treatments and answering outstanding questions in the field, neuroscientists need to be conversant in many different levels of inquiry from neurobiology to cognitive neuroscience to computational neuroscience.

The Dietrich College of Humanities & Social Sciences and the Mellon College of Science have joined forces to establish an exciting interdisciplinary program leading to a Bachelor of Science in Neuroscience. The goal of this degree program is to provide an intensive interdisciplinary education to enable outstanding students to become leaders in identifying and solving tomorrow's Neuroscience problems using a variety of methods. The program's interdisciplinary curriculum is designed for students to gain a fundamental understanding of brain function on many different levels and to begin to specialize within the broad field of Neuroscience. Students in Mellon College of

Science, Dietrich College, or Science and Humanities Scholars Program may have a primary major in Neuroscience in any of the three concentrations. Students from other colleges may have a second major in Neuroscience in any of the three concentrations, subject to double-counting restrictions.

A degree in neuroscience provides excellent preparation for medical school or other graduate programs in the health professions. These students are aided by the Carnegie Mellon Health Professions Program (HPP), an advisory and resource service for all Carnegie Mellon students who are considering careers in the health care field. (See the HPP (<http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#healthprofessionsprogram>) section in this catalog or www.cmu.edu/hpp for more information.)

Students wishing to pursue the Neuroscience major through Dietrich College should contact Dr. Lori Holt (loriholt@cmu.edu). Students wishing to pursue the Neuroscience major through the Mellon College of Science should contact Dr. Maggie Braun (mabraun@andrew.cmu.edu). Students wishing to pursue an additional major in either the Neurobiology or Computational Neuroscience concentrations should contact Dr. Maggie Braun (mabraun@andrew.cmu.edu). Students wishing to pursue an additional major in the Cognitive Neuroscience concentration should contact Dr. Lori Holt (loriholt@cmu.edu).

Students who pursue this major will:

- Gain a broad understanding of Neuroscience at many different levels of analysis, including: cellular biology of the brain, brain systems, cognitive brain function, and computational brain modeling
- Gain an understanding of the sciences underlying Neuroscience, including: Biology, Chemistry, Computer Science, Cognition and Psychology, and other emerging areas
- Develop a comprehensive understanding of brain function in health and disease
- Be familiar with neuroanatomy & neurophysiology and their implications for nervous system function
- Be prepared for advanced study in neurobiology, cognitive neuroscience, and/or neural computation
- Be able to collaborate with Neuroscientists across a wide range of systems and levels of analysis
- Prepare for careers in Neuroscience related companies, Neuroscience research, and/or medicine
- Be prepared for specialization within subfields of Neuroscience given their concentration selection

Requirements for a B.S. in Neuroscience

All students must complete the following:

1. General Science Requirements (see section A)
2. Core Neuroscience Courses (see section B)
3. Requirements for one concentration (see sections C, D, or E)*
4. 18 additional relevant course hours in their home concentration or other neuroscience areas (some examples listed in sections C, D, E, & F). At least 9 of these hours must be at the 300-level or above.
5. Their home college's General Education requirements
6. Free elective hours to come to a total of 360 total course hours

* Students may NOT do two concentrations, but may minor in a related area subject to double-counting restrictions

A. General Science Requirements

	Units
21-120 Differential and Integral Calculus	10
21-122 Integration and Approximation	10
or 21-124 Calculus II for Biologists and Chemists	
03-121 Modern Biology	9
03-330 Genetics	9
09-105 Introduction to Modern Chemistry I	10
09-106 Modern Chemistry II	10
33-111 Physics I for Science Students	12
09-217 Organic Chemistry I**	9
or 33-112 Physics II for Science Students	
or 33-122 Physics II for Biological Sciences and Chemistry Students	
09-221 Laboratory I: Introduction to Chemical Analysis**	12
or 03-124 Modern Biology Laboratory	
15-112 Fundamentals of Programming and Computer Science	12
or 15-110 Principles of Computing	

36-201 Statistical Reasoning and Practice*	9
or 36-217 Probability Theory and Random Processes	
or 36-247 Statistics for Lab Sciences	
or 36-225 Introduction to Probability Theory	

112

* Computational Neuroscience concentration students are required to complete 21-122, 15-112, & 36-217

** Neurobiology concentration students are required to complete 09-217 & 09-221

B. Core Neuroscience Courses

	Units
85-219 Biological Foundations of Behavior	9
or 03-161 Molecules to Mind	
85-211 Cognitive Psychology	9
or 85-213 Human Information Processing and Artificial Intelligence	
03-362 Cellular Neuroscience	9
03-363 Systems Neuroscience*	9
15-386 Neural Computation*	9
or 85-419 Introduction to Parallel Distributed Processing	
or 86-375 Computational Perception	

45

* Computational Neuroscience concentration students are required to complete 15-386.

C. Neurobiology concentration

Didactic Core: Students must complete all of the following*	Units
03-231 Biochemistry I	9
03-240 Cell Biology	9
03-260 Neurobiology of Disease	9
or 03-365 Neural Correlates of Learning and Memory	

27

* Neurobiology concentration students must complete 09-217 and 09-221 in their General Science Requirements (section A, above)

Required laboratory, data analysis, & methodological courses	Units
03-343 Experimental Techniques in Molecular Biology	12
03-346 Experimental Neuroscience Experimental Neuroscience	12
or 03-345 Experimental Cell and Developmental Biology	

24

Electives in Neurobiology (minimum of 9 additional hours)	Units
03-250 Introduction to Computational Biology	12
03-251 Introduction to Computational Molecular Biology	6
03-252 Introduction to Computational Cell Biology	6
03-260 Neurobiology of Disease	9
03-350 Developmental Biology	9
03-364 Developmental Neuroscience	9
03-365 Neural Correlates of Learning and Memory	9
03-439 Introduction to Biophysics	9
09-218 Organic Chemistry II	9
09-222 Laboratory II: Organic Synthesis and Analysis	12
42-202 Physiology	9
42-203 Biomedical Engineering Laboratory NOTE: VERY Limited Seating Available for 42-203	9

D. Cognitive Neuroscience concentration

Didactic Core: Students must complete all of the following:	Units
85-102 Introduction to Psychology	9
36-309 Experimental Design for Behavioral and Social Sciences	9

18

Required laboratory, data analysis, & methodological courses	Units
85-310 Research Methods in Cognitive Psychology	9

85-314	Cognitive Neuroscience Research Methods	9
		18
Electives in Cognitive Neuroscience (minimum of 27 additional hours)**		Units
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-261	Abnormal Psychology	9
85-356	Music and Mind: The Cognitive Neuroscience of Sound	9
85-370	Perception	9
85-390	Human Memory	9
85-406	Autism: Psychological and Neuroscience Perspectives	9
85-408	Visual Cognition	9
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing *	9
85-424	Hemispheric Specialization: Why, How and What?	9
85-426	Learning in Humans and Machines	9
85-429	Cognitive Brain Imaging	9
85-442	Health Psychology	9
85-501	Stress, Coping and Well-Being	9

* If not used as a core course

** At least 18 of these hours must be 300 level or above

E. Computational Neuroscience concentration

Didactic Core. Students must complete all of the following*:		Units
21-127	Concepts of Mathematics	10
15-122	Principles of Imperative Computation	10
or 15-150	Principles of Functional Programming	
21-241	Matrices and Linear Transformations	10
or 21-240	Matrix Algebra with Applications	
		30

* Computational Neuroscience concentration students must complete 21-122, 15-112, and 36-217 in their General Science Requirements (section A, above) and 15-386 in their Core Neuroscience Courses (section B, above). Students must complete a minimum of 60 units in this concentration. Students should select their required laboratory and elective courses to complete a minimum of 31 units (Four 9 unit courses or a lesser number of 9 and 12 unit courses could be combined to complete this requirement).

Required laboratory, data analysis, and methodological courses (18-24 total units)		Units
42-631	Neural Data Analysis	9
or 86-631	Neural Data Analysis	
42-632	Neural Signal Processing	12
15-486	Artificial Neural Networks	12
15-494	Special Topic: Cognitive Robotics	12
15-883	Computational Models of Neural Systems	12
Electives in Cognitive Neuroscience (minimum of 9 units) *		Units
03-512	Computational Methods for Biological Modeling and Simulation	9
or 02-512	Computational Methods for Biological Modeling and Simulation	
10-601	Introduction to Machine Learning	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-387	Computational Perception	9
15-451	Algorithm Design and Analysis	12
15-453	Formal Languages, Automata, and Computability	9
15-486	Artificial Neural Networks	12
15-494	Special Topic: Cognitive Robotics	12
15-883	Computational Models of Neural Systems	12
16-299	Introduction to Feedback Control Systems	12
16-311	Introduction to Robotics	12
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
21-259	Calculus in Three Dimensions	9

21-272	Introduction to Partial Differential Equations	9
21-341	Linear Algebra	9
36-208	Regression Analysis	9
36-226	Introduction to Statistical Inference	9
36-350	Statistical Computing	9
36-401	Modern Regression	9
36-462	Special Topics: Data Mining	9
42-631	Neural Data Analysis	9
or 86-631	Neural Data Analysis	
42-632	Neural Signal Processing	12
F. Examples of Additional Electives relevant to major		
33-112	Physics II for Science Students ^{unless used for Science Core (section A)}	12
33-122	Physics II for Biological Sciences and Chemistry Students ^{unless used for Science Core (section A)}	9
76-385	Introduction to Discourse Analysis	9
80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-220	Philosophy of Science	9
80-254	Analytic Philosophy	9
80-270	Philosophy of Mind	9
80-280	Linguistic Analysis	9
80-314	Logic and Artificial Intelligence	9
88-355	Social Brains: Neural Bases of Social Perception and Cognition	9

NOTE: this list is not restrictive. Concentration advisors can approve additional elective courses that contribute to the student's neuroscience education, subject to additional approval by the major steering committee.

* NOTE: Up to 9 units of applicable undergraduate research course work (e.g. 03-445 or 85-507/85-508) can count as a neuroscience elective (not towards a concentration). A maximum of 27 additional units can be counted as a free electives.

Free Electives (depending on concentration college)	51-61
TOTAL hours to degree	360

* NOTE: Up to 9 units of applicable undergraduate research course work (e.g. 03-445 or 85-507/85-508) can count as a neuroscience elective (not towards a concentration). A maximum of 27 additional units can be counted as a free electives.

Major in Psychology & Biological Sciences

This major is intended to reflect the interdisciplinary nature of current research in the fields of biology and psychology, as well as the national trend in some professions to seek individuals broadly trained in both the social and natural sciences.

Note: Students entering from the College of Humanities and Social Sciences will earn a Bachelor of Science in Psychology and Biological Sciences. Students in the Mellon College of Science will earn a Bachelor of Science in Biological Sciences and Psychology. Students in the joint Science and Humanities Scholars (SHS) program can complete the SHS educational core and choose either departmental order for their diploma.

Depending on a student's home college (H&SS or MCS), General Education (GenEd) requirements will be different. GenEd requirements for H&SS (p. 202) and MCS (p. 307) are found on their respective Catalog pages.

Degree Requirements:

Biological Sciences		Units
03-121	Modern Biology	9
03-231	Biochemistry I	9
03-240	Cell Biology	9
03-330	Genetics	9
03-343	Experimental Techniques in Molecular Biology	12
03-411	Topics in Research	1
03-412	Topics in Research	1
03-xxx	General Biology Elective	9
03-3xx	Advanced Biology Elective	9

03-3xx	Advanced Biology Elective	9
Total Biology units		77
Mathematics, Statistics, Physics and Computer Science Units		
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
36-247	Statistics for Lab Sciences	9
or 36-201	Statistical Reasoning and Practice	
36-309	Experimental Design for Behavioral and Social Sciences	9
33-111	Physics I for Science Students ^{MCS students must complete Physics II also (either 33-112 or 33-122)}	12
15-110	Principles of Computing *	10
99-10x	Computing at Carnegie Mellon	3
Total Science units		63
Chemistry Units		
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
or 09-219	Modern Organic Chemistry	
09-218	Organic Chemistry II	9
or 09-220	Modern Organic Chemistry II	
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
Total Chemistry units		62
Psychology Courses Units		
85-102	Introduction to Psychology	9
85-219	Biological Foundations of Behavior	9
85-2xx	Survey Psychology Courses **	18
85-310	Research Methods in Cognitive Psychology	9
or 85-340	Research Methods in Social Psychology	
or 85-320	Research Methods in Developmental Psychology	
or 85-314	Cognitive Neuroscience Research Methods	
or 85-330	Analytic Research Methods	
85-3xx	Advanced Psychology Electives	18
Total Psychology units		63
** Excluding 85-261 Abnormal Psychology		
Additional Advanced Elective		
9 units(Choose one of the following courses)		
85-3xx	Advanced Psychology Elective	9
or		
03-3xx	Advanced Biology Elective	9
Additional Laboratory or Research Methods		
9-12 units(Choose one of the following courses)		
03-344	Experimental Biochemistry	12
03-345	Experimental Cell and Developmental Biology	12
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	9
85-340	Research Methods in Social Psychology	9
Elective Units Units		
Free Electives		33-36
MCS Nontechnical Breadth or DC General Education requirements		36-48
Total Elective units		0
360		
Minimum number of units required for degree:		

Science and Humanities Scholars Program

Sponsored by the Dietrich College of Humanities and Social Sciences and by the Mellon College of Science
Dr. William Alba, Director

Office: Doherty Hall, Room 2201
www.cmu.edu/shs

The Science and Humanities Scholars (SHS) Program supports undergraduate students seeking to build their education upon a solid academic foundation in the humanities, social sciences, natural sciences, and mathematics. Students in the program, whether formally enrolled in the Mellon College of Science (MCS) or the Dietrich College of Humanities and Social Sciences (DC), can readily access the resources of both colleges. The SHS General Education curriculum enables students to prepare for any field of study in two colleges while exploring the entire university.

Science and Humanities Scholars in their first year may choose to live in a Stever House residential cluster that promotes the integration of academic and social interests. The program additionally provides students with interdisciplinary and multidisciplinary courses and activities.

Before a student declares a major, the Program Director serves as the student's primary academic advisor, complementing the range of other advising opportunities available around the university. After a student declares a major, the Director continues to provide supplementary advising for the student, especially on matters of General Education.

Entering first-year students who apply to DC or MCS with outstanding credentials may receive an invitation to the SHS Program. Invited students should carefully consider whether this academic program matches their own scholarly interests. Students enrolled in either college may also request to transfer into the Science and Humanities Scholars Program after completing at least one semester at the university.

Science and Humanities Scholars General Education Program

The requirements in the SHS General Education Program are designed to expose students to a variety of subjects and methodologies, in order to enable them to become better citizens of the world and more complete scholars. The curriculum permits flexibility and independence in selecting courses to fulfill these General Education requirements; students in the Program may petition the Director to take alternate courses in addition to the ones listed here.

Mathematical Sciences (20 units)

		Units
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	

Statistical Reasoning (9 units)

Students may select one of the following courses **or** any other Statistics course at the 200- level or higher.

36-247	Statistics for Lab Sciences	9
21-325	Probability	9
36-201	Statistical Reasoning and Practice	9
36-217	Probability Theory and Random Processes	9
36-225	Introduction to Probability Theory	9

Writing/Expression (9 units)

Language is a tool used to communicate, as well as a way to organize thinking. This university-wide requirement, to be completed in the first year, focuses on the social nature of language and the ways in which writing constitutes thinking.

76-101	Interpretation and Argument	9
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World Cultures (9 units)

This requirement seeks to enable students to recognize how cultures have shaped and continue to shape the human experience, as well as analyze material that provide clues as to how these cultures operate.

79-104	Global Histories	9
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Freshman Seminar (6-9 units)

Students may select seminars offered by the SHS Program, Dietrich College, and the Mellon College of Science, from a list of courses provided every semester. Past and present SHS seminars include:

99-241	Revolutions of Circularity	9
99-242	Meaning Across the Millennia	9
99-243	Light from the Enlightenment	
99-245	Energy: Science, Society and Communication	9

Computational Reasoning (9-12 units)

Students may select one of the following courses offered in Computer Science, Mathematical Sciences, Philosophy, or related fields.

21-127	Concepts of Mathematics	10
21-128	Mathematical Concepts and Proofs	12
80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-212	Arguments and Logical Analysis	9
15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
15-104	Introduction to Computing for Creative Practice	10
15-121	Introduction to Data Structures	10
15-122	Principles of Imperative Computation	10
02-201	Programming for Scientists	12

Science Core (28 units)

Choose three of the following courses. Science majors with primary majors in the Mellon College of Science must complete at least two that are outside of their major department.

03-121	Modern Biology	9-10
or 03-151	Honors Modern Biology	
03-230	Intro to Mammalian Physiology	9
or 42-202	Physiology	
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
33-111	Physics I for Science Students	12
or 33-151	Matter and Interactions I	
33-112	Physics II for Science Students	12
or 33-152	Matter and Interactions II	

Distribution Requirements (36 units)

Choose a minimum of four courses, 9 units per category, totaling at least 36 units. Below are examples of courses satisfying these categories. You are encouraged to identify other courses that could fulfill these requirements; see the SHS Director for prior approval.

Cognition, Choice, and Behavior

Courses in this category use model-based analysis to broaden an understanding of human thinking, choices, and behavior on an individual basis across a variety of settings. The following list includes examples from Philosophy, Psychology, and Social and Decision Sciences.

80-130	Introduction to Ethics	9
80-150	Nature of Reason	9
80-180	Nature of Language	9
80-221	Philosophy of Social Science	9
80-230	Ethical Theory	9
80-241	Ethical Judgments in Professional Life	9
80-270	Philosophy of Mind	9
85-102	Introduction to Psychology	9
85-211	Cognitive Psychology	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9
85-261	Abnormal Psychology	9
88-120	Reason, Passion and Cognition	9

Economic, Political, and Social Institutions

Courses in this category examine the ways in which institutions organize individual preferences and actions into collective outcomes using model-based reasoning. The following list includes examples primarily from Economics, History, and Social and Decision Sciences; similar courses in those and other departments may also fulfill this requirement.

36-303	Sampling, Survey and Society	9
70-332	Business, Society and Ethics	9
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
79-266	Russian History: From Communism to Capitalism	9
79-331	Body Politics: Women and Health in America	9

80-135	Introduction to Political Philosophy	9
79-350	Early Christianity	9
80-135	Introduction to Political Philosophy	9
80-136	Social Structure, Public Policy & Ethics	9
80-235	Political Philosophy	9
80-341	Computers, Society and Ethics	9
84-104	Decision Processes in American Political Institutions	9

Creative Production and Reflection

Courses in this category encourage exploration of the artistic and intellectual creation of others while allowing for personal expression and reflection upon the creative process.

xx-xxx	Courses from the College of Fine Arts (Architecture 48-xxx, Design 51-xxx, Drama 54-xxx, Music 57-xxx, Art 60-xxx, CFA Interdisciplinary 62-xxx)	Var.
76-260	Survey of Forms: Fiction	9
76-262	Survey of Forms: Nonfiction	9
76-265	Survey of Forms: Poetry	9
76-269	Survey of Forms: Screenwriting	9
79-345	The Roots of Rock and Roll	9
80-220	Philosophy of Science	9
82-1xx	Any Elementary Modern Language course	
82-2xx	Any Intermediate Modern Language course	
99-241	Revolutions of Circularity	9
99-242	Meaning Across the Millennia	9

Cultural Analysis

Courses in this category explore definitions of culture and the role culture plays in producing different actions and institutions, as well as the roles of institutions, systems, and human actions in shaping cultural contexts.

57-173	Survey of Western Music History	9
70-342	Managing Across Cultures	9
76-227	Comedy	9
76-232	Introduction to African American Literature	9
76-241	Introduction to Gender Studies	9
79-201	Introduction to Anthropology	9
79-240	The Development of American Culture	9
79-207	Development of European Culture	9
79-345	The Roots of Rock and Roll	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-224	Mayan America	9
79-261	Chinese Culture and Society	9
79-330	Medicine and Society	9
80-100	Introduction to Philosophy	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-261	Empiricism and Rationalism	9
82-273	Introduction to Japanese Language and Culture	9
82-294	Topics in Russian Language and Culture	9
82-303	Introduction to French Culture	9
82-304	The Francophone World	9
82-333	Introduction to Chinese Language and Culture	Var.
82-342	Spain: Language and Culture	9
82-343	Latin America: Language and Culture	9
82-344	U.S. Latinos: Language and Culture	9
82-345	Introduction to Hispanic Literary and Cultural Studies	9
82-396	The Faust Legend at Home and Abroad	Var.
82-415	Topics in French and Francophone Studies	9
82-426	Topics in German Literature and Culture	9
82-451	Studies in Latin American Literature and Culture	9
82-491	Topics in Twentieth-Century Russian Literature	9

BXA Intercollege Degree Programs

M. Stephanie Murray, Director
Solar Decathlon House
<http://www.cmu.edu/interdisciplinary>

Mission Statement

The BXA Intercollege Degree Programs are designed for students who want to turn talent and passion into viable professions for the future through a challenging academic regimen. BXA students pursue their goals with the help of multifaceted advising, innovative pedagogical strategies, and a focus on the impact arts have on technology and vice versa.

The goal of the Bachelor of Humanities and Arts (BHA), the Bachelor of Science and Arts (BSA), and the Bachelor of Computer Science and Arts (BCSA) BXA Intercollege Degree Programs is to allow a select group of students who demonstrate interest and accomplishment in the fine arts and the humanities, social sciences, natural sciences, computer science, and emerging media to explore beyond the traditional academic major, or integrate more than one field of study across disciplines. These programs foster the creativity of students who explore innovative approaches to the academic environments of two colleges. By merging the components in the arts and humanities, natural sciences, or computer science into an interdisciplinary/multidisciplinary study, a unique, complex product is born. BXA students produce new information, challenging questions, and innovative theory. BXA students are models of independence, motivation, and well-rounded scholarship as humanists, scientists, and artists at the same time.

In the context of the Carnegie Mellon University environment, the BXA Intercollege Degree Programs hold a special role. BXA provides access to four strong colleges that offer specialized training with expert faculty and researchers. The BXA Programs challenge students to utilize those resources as they explore and develop their own approach to interdisciplinary studies in the fine arts and the humanities and social sciences, the natural and mathematical sciences, or computer science.

BXA students balance courses in their CFA concentration with courses in their academic concentration, as well as BXA-specific courses. These BXA-specific courses give students the opportunity to integrate their areas of concentration by focusing on interdisciplinary approaches and arts-based research techniques. The curricula in the concentration areas provide students with a solid disciplinary foundation upon which they can draw for interdisciplinary projects.

A BXA Intercollege degree prepares students for graduate study and careers in an enormous variety of fields, including traditional graduate training in the arts as well as academic areas, positions in arts and education non-profits such as museums and foundations, and technical positions with media and technology companies.

Program Objectives

The skills developed by BXA students span the creative, the technical, the academic, and the practical. The objective of the BXA Intercollege Program is to prepare graduates for careers in which they will draw on their creative and academic skills to create, educate, communicate, and innovate across disciplines.

Students who complete the BXA curriculum will graduate with the following skills:

- Foundational knowledge and technical expertise in the CFA concentration area and the DC/MCS/SCS concentration area
- Ability to describe the connections between these concentrations and how the student integrates them
- Ability to communicate ideas textually, visually, and orally
- Knowledge of how the concentration disciplines intersect with history, society, and culture from local and global perspectives
- Ability to use cognitive, behavioral, and ethical dimensions within the concentration disciplines to make decisions on individual and social levels
- Experience in engaging in art research to produce new knowledge both within the CFA concentration and the DC/MCS/SCS concentration
- Experience in designing, researching, and completing a large-scale, object-based project that integrates both areas of concentration

Bachelor of Humanities and Arts Degree Program

Carnegie Mellon University offers an intercollege degree that combines the strengths of the College of Fine Arts (CFA) and the College of Dietrich College of Humanities and Social Sciences (DC). The intercollege degree, called the Bachelor of Humanities and Arts (BHA), offers depth of study in both the fine arts and the humanities, social and behavioral sciences. The BHA Degree Program enables a student to receive broader exposure to the humanities and liberal arts than is generally possible through a Bachelor of Fine Arts degree in CFA, while obtaining deeper and more substantial training in the fine arts than is generally possible through a Bachelor of Arts or Bachelor of Science degree in DC. Students receive extensive training in one or more of the fine arts disciplines as well as related advanced training in areas such as writing, social sciences, behavioral sciences, or cultural studies. The program also provides enough flexibility to allow students to explore other areas of interest. The most important aspect of the BHA Program is for students to blend their interests, and to explore the connections between their chosen disciplines.

The BHA curriculum is divided into three parts: 1) BHA General Education coursework, 2) CFA concentration coursework, and 3) DC concentration coursework.

Students choose their fine arts concentration from among the five schools in CFA: Architecture, Art, Design, Drama, or Music. A student must meet the entry requirements for the particular CFA school of their choice. While in the BHA Program, a student may change their CFA concentration only if they pass all admission requirements for that particular school.

Students choose their humanities or social/behavioral sciences concentration from the list of majors and minors offered by DC.

The BHA Degree Program is governed by faculty and administrators from both colleges and led by the director of the BXA Intercollege Degree Programs. The director and associate director of the BXA Intercollege Degree Programs are the primary advisors and liaisons between CFA and DC. Students receive extensive advising support. Each student has two additional academic advisors: an advisor in the admitting school of CFA for their fine arts concentration, and an advisor in DC for their humanities/social sciences concentration. This network of advisors guides each student through their curriculum.

Masters of Arts Management (MAM) Option

BHA students who have an interest in arts management and wish to go on for an advanced degree may select courses in their sophomore and junior years to prepare them for this area. A student in the junior year may apply to the Accelerated Master's Program with the School of Public Policy & Management at Heinz College. In this program students take both graduate and undergraduate courses in the senior year, earn the BHA degree, and continue on for an additional year to complete the work for the Masters of Arts Management (MAM) degree.

BHA Curriculum

	Units
I. BHA General Education	111
II. DC Concentration	81
III. CFA Concentration	108
IV. Free Electives	78
Total BHA Degree Requirements	378

I. BHA General Education

(14 courses, 111 units minimum)

- Communicating: Language and Interpretations (3 courses, 27 units minimum, 76-101 required, two approved modern language courses required)
- Reflecting: Societies and Cultures (1 course, 9 units, 79-104 required)
- Modeling: Mathematics and Experiments (1 course, 9 units minimum)

- Deciding: Social Sciences and Values (3 courses, 27 units minimum, 36-201 required)
- Computing @ Carnegie Mellon (1 course, 3 units, 99-101 or 99-102 required)
- BXA Required Courses (5 courses, 36 units minimum, 52-190 and/ or 52-291, 52-391, 52-392, 52-401, 52-402)

Communicating: Language and Interpretations (3 courses, 27 units minimum)

Courses in this category give special attention to the study of language as interpretation, expression and argument within and across multiple discourses. Students examine language for its internal logics and structures.

76-101 Interpretation and Argument 9
(various topics by section) www.cmu.edu/hss/english/first_year/index.html

82-xxx Modern Languages 18
Complete two courses taught in a language offered by the Modern Language Department. A wide selection of courses are offered in Arabic, Chinese Studies, European Studies, French and Francophone Studies, German Studies, Hispanic Studies, Italian, Japanese Studies, Russian Studies, and Spanish. Students must complete two courses in the same language. Languages taught at other institutions are also acceptable (with advisor approval).

Reflecting: Societies and Cultures (1 course, 9 units)

This category emphasizes the study of history, society, and culture from local and global perspectives.

79-104 Global Histories 9
(various topics by section) <http://www.history.cmu.edu/undergraduate/fall.html>

Modeling: Mathematics and Experiments (1 course, 9 units minimum)

Courses in this category stress the interplay of mathematical (formal) theories and experimental work. Some courses investigate the internal structure of theories, whereas others use them as models for producing real-world knowledge. Such models may be drawn from a variety of disciplines including the natural sciences, but also, for example, psychology and computer science. The interactions between theorizing and experimenting (observing) can be understood within an intellectual framework that invites comparative assessment. Select one course from the following course options:

Mathematics

21-110	Problem Solving in Recreational Mathematics	9
21-111	Calculus I	10
21-112	Calculus II *	10
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation *	10
21-127	Concepts of Mathematics	10
21-241	Matrices and Linear Transformations	10
21-256	Multivariate Analysis *	9
21-257	Models and Methods for Optimization *	9
21-259	Calculus in Three Dimensions *	9
80-110	Nature of Mathematical Reasoning	9
80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-212	Arguments and Logical Analysis	9

Natural Science

02-223	Personalized Medicine: Understanding Your Own Genome	9
02-250	Introduction to Computational Biology *	12
02-261	Quantitative Cell and Molecular Biology Laboratory	9
03-121	Modern Biology	9
03-125	Evolution	9
03-132	Basic Science to Modern Medicine	9
03-161	Molecules to Mind	9
03-230	Intro to Mammalian Physiology *	9
03-231	Biochemistry I *	9
03-232	Biochemistry I *	9

03-250	Introduction to Computational Biology *	12
03-362	Cellular Neuroscience *	9
03-363	Systems Neuroscience *	9
09-101	Introduction to Experimental Chemistry	3
09-103	Atoms, Molecules and Chemical Change	9
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II *	10
09-217	Organic Chemistry I *	9
09-218	Organic Chemistry II *	9
09-221	Laboratory I: Introduction to Chemical Analysis *	12
09-222	Laboratory II: Organic Synthesis and Analysis *	12
12-201	Geology	9
33-100	Basic Experimental Physics	6
33-104	Experimental Physics	9
33-106	Physics I for Engineering Students *	12
33-107	Physics II for Engineering Students *	12
33-111	Physics I for Science Students *	12
33-112	Physics II for Science Students *	12
33-114	Physics of Musical Sound	9
33-115	Physics for Future Presidents	9
33-124	Introduction to Astronomy	9
33-131	Matter and Interaction I *	12
33-132	Matter and Interactions II *	12
33-211	Physics III: Modern Essentials *	10
33-213	Mini-Course in Special Relativity *	4
33-224	Stars, Galaxies and the Universe *	9
33-355	Nanoscience and Nanotechnology *	9

Other Courses

02-223	Personalized Medicine: Understanding Your Own Genome	9
05-413	Human Factors	9
06-100	Introduction to Chemical Engineering *	12
09-109	Kitchen Chemistry Sessions	3
09-209	Kitchen Chemistry Sessions *	3
12-100	Introduction to Civil and Environmental Engineering	12
15-104	Introduction to Computing for Creative Practice	10
15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
15-121	Introduction to Data Structures *	10
18-100	Introduction to Electrical and Computer Engineering	12
19-101	Introduction to Engineering and Public Policy *	12
24-101	Fundamentals of Mechanical Engineering *	12
27-100	Engineering the Materials of the Future	12
33-120	Science and Science Fiction	9
36-202	Statistical Methods *	9
42-101	Introduction to Biomedical Engineering *	12
80-220	Philosophy of Science	9
80-222	Measurement and Methodology	9
80-226	Revolutions in Science	9
80-312	Philosophy of Mathematics *	9
80-322	Philosophy of Physics	9
80-323	Philosophy of Biology	9
85-355	Introduction to Cognitive Neuroscience *	9
85-370	Perception	9
85-392	Human Expertise *	9
85-406	Autism: Psychological and Neuroscience Perspectives	9
85-412	Cognitive Modeling *	9
85-414	Cognitive Neuropsychology *	9
85-419	Introduction to Parallel Distributed Processing *	9
85-423	Cognitive Development *	9
85-429	Cognitive Brain Imaging *	9
88-360	Behavioral Economics	9
88-391	Technology and Economic Growth	9
99-238	Materials, Energy and Environment	9

* Indicates co-requisites and/or prerequisites required.

Deciding: Social Sciences and Values (3 courses, 27 units minimum)

The theme of this category is the exploration of cognitive, behavioral and ethical dimensions of decision-making on both the individual and social level. Making decisions requires a broad understanding of human rationality and social interaction. Some courses examine the critical collection and analysis of data for achieving such an understanding, whereas others emphasize the historical development of policies and values, which form the matrix for decision-making.

36-201	Statistical Reasoning and Practice -REQUIRED	9
08-200/19-211	Ethics and Policy Issues in Computing	9
36-207	Probability and Statistics for Business Applications	9
36-220	Engineering Statistics and Quality Control *	9
36-247	Statistics for Lab Sciences *	9
36-303	Sampling, Survey and Society *	9
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics *	9
73-328	Health Economics *	12
73-433	Environmental Policy and Economics *	9
73-469	Global Electronic Markets: Economics and the Internet	9
79-342	Introduction to Science and Technology Studies	9
80-130	Introduction to Ethics	9
80-136	Social Structure, Public Policy & Ethics	9
80-208	Critical Thinking	9
80-221	Philosophy of Social Science	9
80-230	Ethical Theory	9
80-235	Political Philosophy	9
80-241	Ethical Judgments in Professional Life	9
80-242	Conflict and Dispute Resolution	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
80-270	Philosophy of Mind	9
80-271	Philosophy and Psychology	9
80-305	Rational Choice	9
80-321	Causation, Law, and Social Policy *	9
80-324	Philosophy of Economics	9
80-335	Deliberative Democracy: Theory and Practice	9
80-337	Philosophy, Politics & Economics	9
80-341	Computers, Society and Ethics	9
80-348	Health Development and Human Rights	9
80-405	Game Theory	9
80-430	Ethics and Medical Research	9
80-447	Global Justice	9
84-104	Decision Processes in American Political Institutions	9
84-330	CMU/WSP: The United States Supreme Court	12
84-331	CMU/WSP: Congress	12
84-334	CMU/WSP: International Policy	12
84-336	CMU/WSP: The Presidency and Executive Branch	12
84-342	CMU/WSP: Fiscal Policy-Making in the U.S.	12
84-346	CMU/WSP: Race and Politics in the American City	12
84-347	CMU/WSP: Lobbying, Money, and Influence in Washington	12
84-348	CMU/WSP: Spies! The Politics of Intelligence	12
84-350	CMU/WSP: Campaigns and Elections	12
84-362	Diplomacy and Statecraft	9
84-380	Grand Strategy in the United States	9
85-102	Introduction to Psychology	9
85-211	Cognitive Psychology	9
85-213	Human Information Processing and Artificial Intelligence	9
85-219	Biological Foundations of Behavior	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9

85-261	Abnormal Psychology	9
85-395	Applications of Cognitive Science	9
88-120	Reason, Passion and Cognition	9
88-363	Behavioral Economics Theory *	9
88-365	Behavioral Economics and Public Policy *	9
88-388	Psychological Models of Decision Making *	9

* Indicates co-requisites and/or prerequisites required.

Computing @ Carnegie Mellon (1 course, 3 units)

This is a mini-course, pass/no pass, to be completed in the first semester.

99-101	Computing @ Carnegie Mellon	3
or 99-102	Computing @ Carnegie Mellon	

BXA Required Courses (5 courses, 36 units minimum)

BXA-specific courses give students the opportunity to integrate their areas of concentration by focusing on interdisciplinary approaches and arts-based research techniques.

52-190	BXA Seminar I: Building the Wunderkammer	9
or 52-291	BXA Seminar II: Building BXA	
52-391	BXA Junior Portfolio	0
52-392	BXA Seminar III: Deconstructing Disciplines	9
52-401	BXA Seminar IV: Capstone Fall	9
52-402	BXA Seminar V: Capstone Spring	9

II. Dietrich College of Humanities and Social Sciences Concentration

(9 courses, 81 units minimum)

Each student meets individually with a BHA DC Academic Advisor to design an 81 unit DC concentration based on existing DC majors/minors. Please refer to the DC section of this catalog to review the individual majors and minors offered. Curriculum for several BHA DC concentration options are outlined below and others will be made available in the BXA office throughout the academic year.

A completed DC Concentration Sheet must be approved by the concentration faculty advisor and submitted to the BXA office by the end of the student's sophomore year.

Anthropology Concentration (81 units minimum)

The BHA concentration in Anthropology offers students training in ethnographic methods and in theoretical understandings of culture. Students examine the evolution, depth, and complexities of ethnography, and explore notions of "culture" in diverse settings, over time and across space. In today's world, students are increasingly aware of the importance of developing a sophisticated approach to culture and its articulation with changes in the domains of the arts, technology, economics, and politics. The BHA concentration in Anthropology provides students with the tools to link artistic practices to various aspects of globalization.

Students in the Anthropology concentration are required to take an introductory course and a methods/theory course (18 units), two regional courses and two topical courses (36 units), two advanced language courses (18 units), and complete a culminating capstone/independent study (9 units).

Introductory and Methods Courses (2 courses, 18 units)

Students must complete 18 units (typically two courses) selecting from the list below.

79-201	Introduction to Anthropology	9
79-297	Dilemmas and Controversies in Anthropology	9
79-380	Ethnographic Methods	9

Anthropological Perspectives (4 courses, 36 units)

Students gain knowledge of specialized theoretical and regional topics by choosing 36 units (typically four courses) selecting from the list below.

79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-224	Mayan America	9

79-235	Caribbean Cultures	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-278	Rights to Representation: Indigenous People and their Media	9
79-295	Race Relations in the Atlantic World	9
79-296	Perspectives on Social Protest	9
79-299	Trafficking Persons: Children in a Global Context	9
79-312	International Human Rights Institutions in Theory and Practice	6
79-314	The Politics and Culture of Memory	9
79-315	Hawai'i: America's Pacific Island State	9
79-317	Art, Anthropology, and Empire	9
79-332	Medical Anthropology	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9

Note: Courses that count toward this category may be taken at another university, and the units transferred to the BHA concentration under the guidance of the BHA Anthropology faculty advisor.

Language Courses (2 courses, 18 units)

Every student is expected to take two upper level (intermediate or above) language courses (18 units). These courses deepen the immersion in a culture or society that the Anthropology concentration provides a student, and should coordinate with the regional courses selected for the concentration.

Capstone/Independent Study (1 course, 9 units)

Every student is required to do a culminating research project; this may be part of an advanced course (9 units). Students should work with the BHA Anthropology faculty advisor to determine the best method for completing the capstone research project. This project may be complementary to the BHA Capstone Project sequence (52-401 and 52-402) that is completed in the senior year.

Cognitive Neuroscience Concentration (81 units minimum)

Cognitive neuroscience is a science concerned with discovering biological bases of psychological functions. It addresses questions of how behavior is produced by neural circuits of the brain and also how those neural circuits are in turn influenced by behavioral experiences. Students with a concentration in Cognitive Neuroscience are expected to learn about existing findings within the field and also to become proficient in how to conduct and analyze scientific investigations directed toward understanding the biological basis of behavior. This includes observing behavior, formulating hypotheses, designing experiments to test these hypotheses, running experiments, performing statistical analyses, and writing reports.

Introductory and Survey Coursework (36 units)

03-121	Modern Biology	9
03-363	Systems Neuroscience	9
85-219	Biological Foundations of Behavior	9
85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	9

Research Methods Training (18 units)

36-309	Experimental Design for Behavioral and Social Sciences	9
85-314	Cognitive Neuroscience Research Methods *	9

* 85-310 Research Methods in Cognitive Psychology may be substituted if necessary.

Distribution Requirements (27 units)

Complete three courses with at least one from each category below.

Approaches to Cognitive Neuroscience:

15-386	Neural Computation	9
15-883	Computational Models of Neural Systems	12
36-746	Statistical Methods for Neuroscience and Psychology	12
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing	9

85-429	Cognitive Brain Imaging	9
<u>Cognitive Neuroscience Electives:</u>		
03-260	Neurobiology of Disease	9
03-362	Cellular Neuroscience	9
03-364	Developmental Neuroscience	9
03-761	Neural Plasticity	9
15-486	Artificial Neural Networks	12
85-356	Music and Mind: The Cognitive Neuroscience of Sound	9
85-370	Perception	9
85-385	Auditory Perception: Sense of Sound	9
85-390	Human Memory	9
85-406	Autism: Psychological and Neuroscience Perspectives	9

Creative Writing Concentration (81 units minimum)

In the Creative Writing concentration, BHA students develop their talents in writing fiction, poetry, and other imaginative forms. While studying with faculty members who are practicing poets and prose writers, students read widely in literature, explore the resources of their imaginations, sharpen their critical and verbal skills, and develop a professional attitude toward their writing. The Creative Writing program is based on a conservatory model, made up of faculty and students who have an intense commitment to their work.

Students in the Creative Writing concentration are required to take two of the introductory Survey of Forms courses, ideally in their sophomore year. Choices include Poetry (76-265), Fiction (76-260), Screenwriting (76-269), and Nonfiction (76-261). In order to proceed into the upper level courses in the major (and in each of the genres), students must do well in these introductory courses (receive a grade of A or B). After completing the Survey of Forms courses, students take four workshops in fiction, poetry, screenwriting, or nonfiction. At least two of the workshops must be taken in a single genre. In the writing workshops, students develop their critical and verbal abilities through close writing and analysis of poems, stories, and other literary forms. Their work is critiqued and evaluated by peers and the faculty.

Survey of Forms Courses (2 courses, 18 units)

76-260	Survey of Forms: Fiction	9
76-261	Survey of Forms: Creative Nonfiction	9
76-265	Survey of Forms: Poetry	9
76-269	Survey of Forms: Screenwriting	9

Note: A student must receive a grade of A or B in the Survey of Forms class in a specific genre in order to be eligible to enroll in a workshop of that genre. A student who receives a grade of C in a Survey of Forms course may enroll in a related workshop only with the permission of the workshop professor. A student who receives a D or R in Survey of Forms may not take a workshop in that genre.

Creative Writing Workshops (4 courses, 36 units)

Complete four Creative Writing workshops, at least two in a single genre. Workshops in all genres may be taken more than once for credit.

76-365	Beginning Poetry Workshop	9
76-366	Beginning Fiction Workshop	9
76-460	Beginning Fiction Workshop	9
76-462	Advanced Fiction Workshop	9
76-464	Creative Nonfiction Workshop	9
76-465	Advanced Poetry Workshop	9
76-469	Advanced Screenwriting Workshop	9
76-4xx	Elective Workshops (various forms)	9

English Electives (3 courses, 27 units)

Complete three courses from the English Department's offerings. Reading in Forms classes are recommended, as is 76-306 Editing and Publishing. Please consult the list of courses published each semester by the Department for current offerings. Students should discuss curriculum choices with the Creative Writing advisor to determine the best electives for their focus in Creative Writing.

Decision Science Concentration (81 units minimum)

Decision Science is grounded in theories and methods drawn from psychology, economics, philosophy, statistics, and management science. Courses in the BHA concentration in Decision Science cover the three aspects of decision science: (a) normative analysis, creating formal models of rational choice; (b) descriptive research, studying how cognitive,

emotional, social, and institutional factors affect judgment and choice, and (c) prescriptive interventions, seeking to improve judgment and decision making. In addition to gaining a broad education in the principles of judgment and decision making, students with a concentration in Decision Science gain broadly applicable skills in research design and analysis. They also have the chance to think about and discuss decision making in many different areas.

Disciplinary Perspectives (5 courses, 45 units)

85-211	Cognitive Psychology	9
88-120	Reason, Passion and Cognition (freshman or sophomore year)	9
88-220	Policy Analysis I	9
88-223	Decision Analysis and Decision Support Systems	9
88-302	Behavioral Decision Making	9

Research Methods (2 courses, 18 units)

36-202	Statistical Methods	9
88-251	Empirical Research Methods	9

Electives (2 courses, 18 units)

Complete at least 18 units from the following categories of courses. The selected courses may be from one category or from any combination of categories. Note that not all elective courses are offered every year. At least one of these courses (9 units) must be a Department of Social and Decision Sciences course (88-xxx).

Biological and Behavioral Aspects of Decision Making:

85-352	Evolutionary Psychology	9
85-377	Attitudes and Persuasion	9
85-442	Health Psychology	9
88-360	Behavioral Economics	9
88-365	Behavioral Economics and Public Policy	9
88-388	Psychological Models of Decision Making	9
88-421	Emotion: Physiology, Neurobiology, Expression, and Decision Making	9
88-442	Decision Science in Intergroup Conflict	9

Managerial and Organizational Aspects of Decision Making:

70-311	Organizational Behavior	9
or 88-260	Organizations	
70-381	Marketing I	9
70-460	Mathematical Models for Consulting	9
88-221	Policy Analysis II	9
88-419	Negotiation	9
88-444	Public Policy and Regulation	9
88-451	Policy Analysis Senior Project	12
or 88-452	Policy Analysis Senior Project	

Philosophical and Ethical Perspectives on Decision Making:

19-426	Environmental Decision Making	9
80-208	Critical Thinking	9
80-221	Philosophy of Social Science	9
80-241	Ethical Judgments in Professional Life	9
80-245	Medical Ethics	9
80-305	Rational Choice	9
80-321	Causation, Law, and Social Policy	9

Economic and Statistical Methods for Decision Science:

70-460	Mathematical Models for Consulting	9
73-347	Game Theory for Economists	9
80-337	Philosophy, Politics & Economics	9
80-405	Game Theory*	9
88-316	Game Theory*	9
88-360	Behavioral Economics	9
88-367	Behavioral Economics in the Wild	9
88-387	Social Norms and Economics	9

* 80-405 and 88-316 are different courses and are not cross-listed.

Decision Science and Public Policy:

88-221	Policy Analysis II	9
88-365	Behavioral Economics and Public Policy	9

88-405	Risk Perception and Communication	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
88-444	Public Policy and Regulation	9
88-451	Policy Analysis Senior Project	12
or 88-452	Policy Analysis Senior Project	

Research Methods for Decision Science:

36-303	Sampling, Survey and Society	9
70-460	Mathematical Models for Consulting	9
88-252	Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9
88-388	Psychological Models of Decision Making	9
88-402	Modeling Complex Social Systems	9
88-435	Decision Science and Policy	9

Economics Concentration (81 units minimum)

The BHA concentration in Economics provides a solid understanding of economic theory and quantitative economic analysis. The introductory core disciplinary sequences in economic theory and quantitative analysis rely on a knowledge base of calculus and statistics. The advanced data analysis component pays additional attention to ordinal data and the study of surveys. Students also study political, historical, cultural, and social institutions within an economic context.

Mathematics Pre-requisites

These courses are not counted as part of your DC Concentration. They may be used to satisfy general education or free elective requirements.

21-120	Differential and Integral Calculus	10
21-256	Multivariate Analysis	9

Economic Theory Requirements (27 units)

73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-270	Writing for Economists	9

Quantitative Analysis Requirements (27 units)

These courses require 36-201 Statistical Reasoning and Practice as a pre-requisite; 36-201 fulfills a general education Deciding requirement, as well.

36-202	Statistical Methods	9
36-303	Sampling, Survey and Society	9
73-240	Intermediate Macroeconomics	9

Advanced Economics Electives (18 units)

Students must take two advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium) as well as courses designated by the program offered by other departments/programs. Additionally, students may work with their economics advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

Senior Project (9 units)

Students will take the Senior Project course in conjunction with the 52-401 BXA Seminar IV: Capstone Fall course in the fall of their senior year.

73-497	Senior Project	9
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English Concentration (81 units minimum)

The BHA concentration in English is distinctive in drawing from the artistic and research strengths of the Department's faculty in Literary and Cultural Studies, Rhetoric, and Creative Writing. Literary and Cultural Studies focuses on the way texts are formally constructed and how they function in historical and contemporary contexts. Creative Writing helps students focus on language as a tool to explore and depict experience. Rhetoric focuses on the principles through which writers construct texts and audiences respond to them. Drawing from all of these perspectives, students with a Concentration in English learn the research skills and writing strategies to enable them to analyze the language and texts of other writers and to report their research in effective texts of their own. Such training can prepare students for graduate work in literature, cultural studies, or rhetoric, and also for careers in law, business, or government, which require similar skills in interpretation, research, and writing.

Introductory Courses (2 courses, 18 units)

The 200-level core courses are designed to introduce students to writing in a variety of genres, to a knowledge of literary and other media forms, and to a basic theoretical knowledge of how texts are produced and interpreted. In the Interpretive Practices course, students are introduced to basic concepts, methods, and practices of literary and rhetorical approaches to texts. In the Survey of Forms course, students learn how to use language to express experience through poetic and narrative forms.

76-26X	Survey of Forms (Nonfiction, Fiction, Poetry, Screenwriting)	9
76-294	Interpretive Practices	9

Research Course (1 course, 9 units)

Research in English offers training in gathering information systematically and in building arguments based on that information. Students will hone their skills in reading texts, using critical commentary, assessing print and electronic materials, and conducting interviews and surveys. They will learn how to test their hypotheses against alternatives and present their research to audiences within the discipline of English. The historical or thematic content of this course will vary from one semester to another. While 76-394 is not a pre-requisite for 400-level courses, it is strongly recommended that students with a BHA concentration in English take this course in their junior year.

76-394	Research in English	9
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Rhetoric Course (1 course, 9 units)

Complete one course from a set of varied offerings in Rhetoric as designated each term by the English Department. Rhetoric courses focus explicitly on language and discourse as objects of study and emphasize the relationships of language, text structure, and meaning within specific contexts.

300-Level Courses (2 courses, 18 units)

Complete two 300-level courses that investigate the production and interpretation of texts and other media from a variety of periods and theoretical and methodological perspectives. Course offerings that meet these requirements are advertised on a semester-by-semester basis. For students with a BHA Concentration in English, 76-294 Interpretive Practices is a prerequisite for these courses. Course options include but are not limited to the following:

76-321	History of the British Novel	9
76-327	Influential Women Writers	9
76-334	Literature of Wall Street	9
76-339	Topics in Film Studies	9
76-341	Gender and Sexuality in Performance	9
76-350	History of Critical Ideas: Reading and Spectatorship	9
76-3xx	Any 300 level course with advisor approval	9

400-Level Courses (2 courses, 18 units)

Complete two 400-level seminar courses that investigate a specific topic in depth and allow students to work on a major research-based paper. Courses in this category will be advertised on a semester-by-semester basis. For students with a BHA Concentration in English, 76-294 Interpretive Practices is a prerequisite and 76-394 Research in English is pre- or co-requisite. Among current course offerings, examples include but are not limited to the following:

76-414	Politics, Media, and Romantic Literature 1789-1830	9
76-430	Arthurian Romance and Its Modern Legacy	9
76-439	Seminar in Film and Media Studies	9
76-445	John Milton: Poetry, Paradise, and Revolution	9
76-453	Literature of Empire	9
76-4xx	Any 400 level course with advisor approval	9

Period Course Requirement

The period course requirement is not a separate course requirement per se but one that needs to be met through the selection of the required 300- and 400-level courses. At least two of these four required courses must be "period" courses, that is, courses that focus on texts that are connected in time and place or through common social concerns. One of these two courses must focus on a historical period prior to 1900. Courses in this category will vary from year to year and be advertised on a semester-by-semester basis. Such courses may be at either the 300- or 400-level.

Elective Course (1 course, 9 units)

Complete one course from the English Department's offerings. This course may be at the 200-, 300-, or 400-level. Electives may include any courses

offered by the English Department with the exception of courses designed for non-majors. Some semester offerings may include cross-listed courses from Modern Languages or History.

Environmental Studies Concentration (81 units minimum)

The concentration in Environmental Studies focuses on human-environment interactions from a multitude of disciplinary perspectives. The curriculum draws on the expertise of faculty across several Carnegie Mellon colleges in order to provide students with the interdisciplinary background and skills necessary to understand environmental problems and the means to mitigate them. It emphasizes three general areas: (1) natural science and technology; (2) social sciences; and (3) the humanities. The flexible curriculum features training in research methods; a set of core courses on fundamental environmental issues including energy, pollution, and biological diversity; and a project course experience geared toward policy formulation. It is recommended that students take 21-111 Calculus I and 36-202 Statistical Methods as prerequisites for higher-level coursework.

Note that some courses carry prerequisites and/or reserve seats for primary majors. Students interested in pursuing the concentration must meet beforehand with the faculty director and their BHA academic advisor in order to map out a course of study. Students are encouraged to be alert to new course offerings; every effort will be made to find equivalent courses that meet student interest when done in consultation with the faculty director.

Foundation of Environmental Sciences (18 units minimum)

Complete one required science course:

03-121	Modern Biology	9
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Choose one of the following courses:

03-124	Modern Biology Laboratory (co-requisite: 03-121)	9
03-125	Evolution	9
09-103	Atoms, Molecules and Chemical Change	9
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10

Disciplinary Perspectives (18 units)

Choose two of the following courses:

09-510	Chemistry and Sustainability	9
73-148	Environmental Economics	9
76-319	Environmental Rhetoric	9
79-374	American Environmental History: Critical Issues	9

Thematic Electives (15 units minimum)

Choose two of the following courses:

12-100	Introduction to Civil and Environmental Engineering	12
19-101	Introduction to Engineering and Public Policy	12
19-424	Energy and the Environment	9
60-203	Concept Studio: EcoArt	10
76-395	Science Writing	9
79-372	Perspectives on the Urban Environment	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
80-348	Health Development and Human Rights	9
88-223	Decision Analysis and Decision Support Systems	9
88-302	Behavioral Decision Making	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
90-765	Cities, Technology and the Environment	6
90-798	Environmental Policy & Planning	12
90-808	Energy Policy	6
90-xxx	Heinz College courses (open to seniors)	

Research and Analytical Methods (18 units)

Choose two of the following courses:

36-309	Experimental Design for Behavioral and Social Sciences	9
79-380	Ethnographic Methods	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
88-220	Policy Analysis I	9

88-251	Empirical Research Methods	9
88-252	Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9
88-432	International Policy Decision Modeling Workshop	9

Project Course (12 units)

Complete one of the following courses:

19-451	EPP Projects (pre-approved sections)	12
19-452	EPP Projects	12

Ethics, History, & Public Policy Concentration (81 units minimum)

The BHA concentration in Ethics, History, & Public Policy (EHPP) provides students with a rigorous, interdisciplinary humanistic and social-scientific education. The concentration in EHPP encourages the development of a broad technical skill set that will benefit students in whatever career they ultimately choose to pursue. Students with a concentration in EHPP learn how to analyze and construct arguments; to evaluate evidentiary statements; to persuade people to agree with their particular claims; to conduct research under time and resource constraints; and to craft policies that address real world problems in a way that is sensitive both to history and competing sets of values. Comprised of courses in the departments of History, Philosophy, Economics, and Decision Science, the BHA concentration in EHPP encourages specialization, internship experiences, and research in a wide range of policy areas.

Economics Requirement (1 course, 9 units)

Choose one of the following courses:

73-100	Principles of Economics	9
88-220	Policy Analysis I	9

History Core (3 courses, 27 units)

Required History Core Courses:

79-200	Introduction to Historical Research	9
79-300	History of American Public Policy	9

Choose one Survey Course:

US Survey		
79-240	The Development of American Culture	9
Non-US Survey		
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-224	Mayan America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-233	The United States and the Middle East since 1945	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-255	Irish History	6
79-256	20th Century Germany	9
79-257	Germany and the Second World War	9
79-258	French History: From the Revolution to De Gaulle	9
79-259	France During World War II	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9

79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9

Philosophy Core (3 courses, 27 units)

Choose one course from three of the four categories below. No more than 18 units at the 100-level may be counted toward this requirement.

Ethics (9 units):

80-130	Introduction to Ethics	9
80-230	Ethical Theory	9

Political Philosophy (9 units):

80-135	Introduction to Political Philosophy	9
80-235	Political Philosophy	9

Foundations of Social Science (9 units):

80-221	Philosophy of Social Science	9
80-321	Causation, Law, and Social Policy	9
80-337	Philosophy, Politics & Economics	9

Applied Philosophy (9 units):

80-136	Social Structure, Public Policy & Ethics	9
80-241	Ethical Judgments in Professional Life	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
80-341	Computers, Society and Ethics	9
80-344	Management, Environment, and Ethics	9
80-348	Health Development and Human Rights	9
80-447	Global Justice	9

Elective Courses (2 courses, 18 units)

Choose any two courses from any of the following categories.

Engineering and Public Policy:

19-424	Energy and the Environment	9
19-426	Environmental Decision Making	9
19-448	Science, Technology & Ethics	9

Business:

70-311	Organizational Behavior	9
70-321	Negotiation and Conflict Resolution	9
70-332	Business, Society and Ethics	9
70-364	Business Law	9
70-365	International Trade and International Law	9
70-430	International Management	9

Economics:

73-148	Environmental Economics	9
73-310	Evolution of Economic Ideas and Analysis	9
73-358	Economics of the Environment and Natural Resources	9
73-359	Benefit-Cost Analysis	9
73-365	Firms, Market Structures, and Strategy	9
73-372	International Money and Finance	9
73-375	History of Money and Monetary Policy	9
73-408	Law and Economics	9
73-476	American Economic History	9

English:

76-492	Rhetoric of Public Policy	9
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History:

79-221	Development and Democracy in Latin America	9
79-231	American Foreign Policy: 1945-Present	9
79-233	The United States and the Middle East since 1945	9
79-242	African American History: Reconstruction to the Present	9

79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-303	Pittsburgh and the Transformation of Modern Urban America	6
79-320	Women, Politics, and Protest	9
79-331	Body Politics: Women and Health in America	9
79-339	Juvenile Delinquency and Film (1920 to "The Wire")	9
79-342	Introduction to Science and Technology Studies	9
79-359	Terrorism and U.S. National Security	6
79-371	African American Urban History	9
79-374	American Environmental History: Critical Issues	9
79-383	Epidemics, Disease, and Public Health	9
79-389	Stalin and Stalinism	9

Philosophy:

80-241	Ethical Judgments in Professional Life	9
80-256	Modern Moral Philosophy	9
80-305	Rational Choice	9
80-341	Computers, Society and Ethics	9
80-344	Management, Environment, and Ethics	9
80-405	Game Theory	9

Social and Decision Sciences:

84-104	Decision Processes in American Political Institutions	9
88-223	Decision Analysis and Decision Support Systems	9
88-343	Economics of Technological Change	9
88-345	Perspectives on Industrial Research and Development	9
88-347	Complex Technological Systems: Past, Present, and Future	9
88-371	Entrepreneurship, Regulation and Technological Change	9
88-387	Social Norms and Economics	9
88-423	Institutions, Entrepreneurship, and Innovation	9
88-444	Public Policy and Regulation	9

Note: Other elective courses may be approved at the discretion of the EHPP faculty advisor and should be noted on a student's DC Concentration Sheet.

Film & Media Studies Concentration (81 units minimum)

Film and the electronic media have become a crucial part of contemporary culture and society; they constitute an important tool for understanding social arrangements, historical changes, and play an increasingly important role in the development of aesthetic and cultural theory. The BHA concentration in Film & Media Studies takes an interdisciplinary approach to the study of film and other electronic media. Courses provide techniques for analyzing and criticizing film and other media, for assessing their value as historical, anthropological and social scientific data, and for understanding the aesthetic and philosophical premises of various media texts. In addition, students may take courses in the processes of film-making, offered through special arrangement with the Pittsburgh Filmmakers (a non-profit media arts center, operating since 1971, that provides workshops, seminars, screenings, exhibitions, and training programs in the media and photographic arts).

The courses listed below are offered with at least general regularity. Participating departments may subsequently develop and offer other courses that, while not listed here, are deemed appropriate for this minor. The minor faculty advisor should be consulted (especially when the schedule of courses to be offered for a given semester becomes available) to identify such additional courses.

Introductory Course (9 units)

76-239	Introduction to Film Studies	9
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Required Intermediate Course (9 units)

76-339	Topics in Film Studies (May be taken up to three times and counted for additional credit toward Intermediate Courses if topics differ.)	9
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Intermediate Courses (27 units)

Complete a minimum of 27 units of course work, chosen in any combination from the following three categories.

Film and the Study of Society:

76-238	Introduction to Media Studies	9
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Film and Anthropology:

79-278	Rights to Representation: Indigenous People and their Media	9
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Filmmaking:

76-269	Survey of Forms: Screenwriting	9
FM 200	Documentary Production (please go to CFA 100 to register for this course)	9

Other 200 or 300 level courses in English, History, and Modern Languages can be counted in this category when their primary topic is film and media. Please consult the Film & Media Studies faculty advisor.

Advanced Courses (36 units)

Complete four advanced courses that concentrate on film directly or that use it as a tool of social or cultural analysis.

FM 301	Advanced Filmmaking (please go to CFA 100 to register for this course)	9
76-438	Film and Media Studies: Television	9
76-439	Seminar in Film and Media Studies	9
76-469	Advanced Screenwriting Workshop	9
82-491	Topics in Twentieth-Century Russian Literature	Var.

Global Studies Concentration (81 units minimum)

The BHA concentration in Global Studies is designed for students interested in humanistic approaches to understanding past and present processes of globalization. Participating faculty in the departments of History, Modern Languages, and English conduct research in Africa, Asia, Europe, Latin America, the Middle East, and the Pacific. The rigorous yet flexible Global Studies curriculum combines anthropology, history, literary and cultural studies, and advanced language training in order to help students make sense of complex interactions among global processes, regional and local cultures, and societal structures. BHA concentration students in Global Studies develop a broad understanding of their prospects and responsibilities as citizens of the world confronting challenging contemporary problems.

There are two required courses for the concentration: Introduction to Global Studies (79-275) and Advanced Seminar in Global Studies (79-400). Students also choose among several courses focused on theory, research methods, transnational histories, and regional/national histories and cultures. Demonstrating intermediate to advanced level proficiency in a language other than English is a crucial component of the major in Global Studies.

In addition to coursework at Carnegie Mellon, BHA students with a concentration in Global Studies are encouraged to incorporate a semester of study abroad into their course of study in order to immerse themselves in society different from their own with unfamiliar cultural practices, language, and history.

Students should consult frequently with the BHA advisor, the Global Studies academic program manager, and with participating faculty who will help students to craft a coherent course of study on specific topics and/or regions that may lead to the capstone research project (79-400 Advanced Seminar in Global Studies), the BXA capstone project (52-401 and 52-402) or a Dietrich College senior honors thesis (<http://hss.cmu.edu/seniorhonorsprogram.html>). Program faculty and the academic program manager will also work with students to connect their academic interests and their participation in student organizations and/or organizations based in Pittsburgh with transnational reach.

Global Studies Introductory and Capstone Courses (2 courses, 21 units)

Students must earn a final grade of "C" or better for these courses to count toward the major.

79-275	Introduction to Global Studies	9
79-400	Advanced Seminar in Global Studies	12

Language Requirement

Demonstrating intermediate to advanced level proficiency in a language other than English is a crucial component of the concentration in Global Studies. Normally this requirement can be satisfied by successfully completing a course conducted in the second language at the 300-level or above for French, German, Italian, or Spanish, or the fourth semester

(Intermediate II) level or above for Arabic, Chinese, Japanese, or Russian. Comparable proficiency for other languages can be considered. Additional advanced cultural, historical, and literary study in the second language is strongly recommended. Courses in a language other than English may also be counted as Global Studies transnational, global, regional courses or Global Studies electives as appropriate.

Theoretical and Topical Core Courses (2 courses, 18 units)

To gain a solid foundation in the theories, methods, and analytical topics underpinning the concentration in Global Studies, students select 18 units (typically two courses) from the core courses listed below. Students must earn a final grade of "C" or better in these courses to fulfill the theoretical and topical core course requirement.

76-453	Literature of Empire	9
76-497	Culture: Interdisciplinary Approaches	9
79-200	Introduction to Historical Research	9
79-278	Rights to Representation: Indigenous People and their Media	9
79-297	Dilemmas and Controversies in Anthropology	9
79-314	The Politics and Culture of Memory	9
79-317	Art, Anthropology, and Empire	9
79-318	Sustainable Social Change: History and Practice	6
79-332	Medical Anthropology	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-376	Doing Transnational History	9
79-377	Food, Culture, and Power: A History of Eating	9
79-380	Ethnographic Methods	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9

Transnational, Global, and Regional Courses (3 courses, 27 units)

To gain insight into how complex transnational and global processes shape and are affected by local, national, and regional dynamics, students will select 27 units (typically three courses) from any subcategories below.

Transnational and Global Courses:

76-322	Global Masala: South Asians in the Diaspora	9
76-353	Global Studies	9
76-440	Postcolonial Theory: Diaspora and Transnationalism	9
76-448	The Global Renaissance	9
79-224	Mayan America	9
79-233	The United States and the Middle East since 1945	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-254	The Jewish Diaspora in Latin America	9
79-276	Beyond the Border	6
79-282	Europe and the World since 1800	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-289	Animal Planet: An Environmental History of People and Animals	6
79-295	Race Relations in the Atlantic World	9
79-299	Trafficking Persons: Children in a Global Context	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-312	International Human Rights Institutions in Theory and Practice	6
79-342	Introduction to Science and Technology Studies	9
79-383	Epidemics, Disease, and Public Health	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
79-385	The Making of the African Diaspora	9
80-348	Health Development and Human Rights	9
80-447	Global Justice	9
82-304	The Francophone World	9
82-345	Introduction to Hispanic Literary and Cultural Studies	9
84-326	Theories of International Relations	9

Regional Courses:

Africa		
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
Eastern and Southern Asia and the Pacific		
76-354	South Asian Literature	9
79-211	East Asia in the World, 1600-Present	9
79-264	Tibet in History and Imagination	9
82-431	China and the West	9
88-411	Rise of the Asian Economies	9
Europe		
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-268	World War I: The Twentieth Century's First Catastrophe	9
79-323	Family, Gender, and Sexuality in European History, 500-1800	9
82-320	Contemporary Society in Germany, Austria and Switzerland	9
82-323	Germany, Austria and Switzerland in the 20th Century	9
82-415/416	Topics in French and Francophone Studies	9
82-441	Studies in Peninsular Literature and Culture	9
The Middle East		
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-307	Religion and Politics in the Middle East	9
79-398	Documenting the 1967 Arab-Israeli War	9
82-300	Topics in Cross-Cultural Studies	9
The Americas		
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-235	Caribbean Cultures	9
82-343	Latin America: Language and Culture	9
82-451	Studies in Latin American Literature and Culture	9
82-455/456	Topics in Hispanic Studies	9
<u>Electives</u> (2 courses, 15 units minimum)		
Students are required to take an additional 15 units (typically two courses) of electives, selected from one or both of the subcategories below. "Theoretical and Topical Core Courses" and "Transnational, Global, and Regional Courses" listed above that are not used to fulfill those requirements may be counted as electives in addition to the courses listed below.		
Those students who wish to pursue an optional Global Studies Senior Thesis (9 units) as one of their electives may do so by arrangement with Global Studies faculty; the thesis will often involve work in a language other than English. This option is not to be confused with the two-semester Dietrich College Senior Honors Thesis, for graduating with college-level honors.		
Thematic Courses:		
70-365	International Trade and International Law	9
76-241	Introduction to Gender Studies	9
76-318	Communicating in the Global Marketplace	9
76-386	Language & Culture	9
76-450	Literary and Cultural Theory: Law, Culture, and the Humanities	9
79-201	Introduction to Anthropology	9
79-281	Introduction to Religion	9
79-296	Perspectives on Social Protest	9

79-298	Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal	6
79-301	History of Surveillance: From the Plantation to Edward Snowden	6
79-330	Medicine and Society	9
79-349	The Holocaust in Historical Perspective	9
79-506	Global Studies Internship	9
80-244	Environmental Ethics	9
80-247	Ethics and Global Economics	9
80-335	Deliberative Democracy: Theory and Practice	9
80-344	Management, Environment, and Ethics	9
82-215	Introduction to Modern Arabic Literature and Culture	Var.
82-311	Arabic Language and Culture I	9
82-312	Arabic Language and Culture II	9
82-358	Literacies Across Language and Culture	9
82-541	Special Topics: Hispanic Studies	Var.
84-275	Comparative Politics	9
84-310	International Political Economy and Organizations	9
84-362	Diplomacy and Statecraft	9
88-410	The Global Economy: A User's Guide	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9

Nation-based Courses:

76-337	Intro to Ethnic American Studies	9
79-231	American Foreign Policy: 1945-Present	9
79-315	Hawai'i: America's Pacific Island State	9
79-320	Women, Politics, and Protest	9
79-331	Body Politics: Women and Health in America	9
82-344	U.S. Latinos: Language and Culture	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
82-333	Introduction to Chinese Language and Culture	Var.
82-433	Topics in Contemporary Culture of China	9
82-434	Studies in Chinese Traditions	9
82-440	Studies in Chinese Literature & Culture	9
79-258	French History: From the Revolution to De Gaulle	9
79-259	France During World War II	9
82-303	Introduction to French Culture	9
82-305	French in its Social Contexts	9
79-257	Germany and the Second World War	9
79-326	German History through Film	9
82-327	The Emergence of the German Speaking World	9
82-425	Topics in German Literature and Culture	9
82-427	Nazi and Resistance Culture	9
82-428	History of German Film	Var.
79-319	India through Film	6
79-255	Irish History	6
82-361	Italian Language and Culture I	9
82-362	Italian Language and Culture II	9
82-273	Introduction to Japanese Language and Culture	9
82-278	Japanese Film and Literature: The Art of Storytelling	9
82-473	Topics in Japanese Studies	9
82-474	Topics in Japanese Studies	9
82-253	Korean Culture Through Film	9
82-254	World of Korea, Then and Now	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-389	Stalin and Stalinism	9
82-293	Introduction to Russian Culture	9
82-294	Topics in Russian Language and Culture	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
82-342	Spain: Language and Culture	9

International Relations and Politics Concentration (81 units minimum)

The International Relations and Politics (IRP) BHA concentration analyzes the role of politics at the national, regional, international, and transnational levels; examines political and institutional arrangements within and among these levels; and investigates the grand strategy of nation-states.

Statesmen, scholars, and policy makers often define grand strategy as the combination of diplomatic, economic, military, and political factors used by leaders to defend their respective nation-states. The IRP major investigates the way in which leaders and citizens construct grand strategy and national security policy more generally; the impact of domestic and international forces on states' security and economic policies; and the significance of alliances, coalitions, and international institutions for world politics.

Although the study of grand strategy and political institutions is the flagship initiative of the concentration, students are also able to study the effects of culture, economics, and society on the international system through a rich set of elective courses.

Thinking systematically about international and domestic politics is the core objective of the IRP concentration. The concentration is rooted in the discipline of political science but also utilizes the interdisciplinary strengths of behavioral decision science, complex social systems, economics, strategy, entrepreneurship and technological change, and political history. Thus, students pursuing this concentration will use the analytic tools of game theory, economic and statistical analysis, qualitative analysis, rational choice theory, and theories of behavioral decision making as they study alliances, coalitions, institutions, and political strategy.

Recognizing the influence of language and culture on politics, students are required to complete the intermediate (200) level, or its equivalent, in a modern language other than English. Advanced-level study is strongly encouraged.

Open to all Carnegie Mellon undergraduates, the Carnegie Mellon University Washington Semester Program (CMU/WSP) allows students to study public policy and intern in Washington for one semester. Courses taken through CMU/WSP will count toward the elective sequence in public policy for IRP concentration.

Students' understanding of politics is further informed by courses and colloquia offered by CMU's top-ranked departments, divisions, and schools in business, computer science, engineering, and the humanities.

IRP students interested in developing their research skills are encouraged to apply for a research position with the Center for International Relations and Politics. They are also encouraged to join student organizations focused on domestic or international politics. Becoming involved in the Institute for Politics and Strategy, as well as attending lectures and events sponsored by the Center for International Relations and Politics will provide additional opportunities for students.

The International Relations and Politics concentration is offered through the Institute for Politics and Strategy.

Core Courses (6 courses, 54 units)

84-104	Decision Processes in American Political Institutions	9
84-265	Political Science Research Methods	9
84-275	Comparative Politics	9
84-326	Theories of International Relations	9
36-202	Statistical Methods	9
73-100	Principles of Economics	9
or 88-220	Policy Analysis I	

Language Requirement

BHA students are required to complete the intermediate (200) level or the equivalent in a modern language other than English. This Language Requirement may be satisfied by the BHA General Education Modern Languages requirement if the 200-level is reached. Advanced level study is strongly encouraged.

Electives (3 courses, 27 units minimum)

International Relations and Politics BHA students will either:

Option 1) take 27 units (three courses) from the elective lists below. Students must take two courses (18 units) from the Grand Strategy and Political Institutions category. The remaining one course (9 units) must come from the Economics and Society or International Cultures categories. At least two courses (18 units) must be from the Institute for Politics and Strategy (84-xxx).

Grand Strategy and Political Institutions (2 courses, 18 units)

19-609 Public Policy and Regulation

19-662	Special Topics: Technology and Development in China & India	12	88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9	88-413	Energy and Climate: History, Science, Technology, & Policy in the US 1776-2076	9
79-218	United States and the World	9	88-419	Negotiation	9
79-231	American Foreign Policy: 1945-Present	9	88-423	Institutions, Entrepreneurship, and Innovation	9
79-298	Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal	6	International Cultures		
79-301	History of Surveillance: From the Plantation to Edward Snowden	6	76-318	Communicating in the Global Marketplace	9
79-302	Drone Warfare: Ethics, Law, Politics, History, and Strategy	6	76-322	Global Masala: South Asians in the Diaspora	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9	76-386	Language & Culture	9
79-359	Terrorism and U.S. National Security	6	79-205	20th Century Europe	9
79-360	Conspiracies, Spies, and Assassins in Revolutionary Europe	6	79-211	East Asia in the World, 1600-Present	9
79-389	Stalin and Stalinism	9	79-221	Development and Democracy in Latin America	9
79-392	History of Modern Warfare	9	79-222	Between Revolutions: The Development of Modern Latin America	9
80-135	Introduction to Political Philosophy	9	79-223	Mexico: From the Aztec Empire to the Drug War	9
80-235	Political Philosophy	9	79-224	Mayan America	9
80-321	Causation, Law, and Social Policy	9	79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
80-335	Deliberative Democracy: Theory and Practice	9	79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
84-210	Comparative Political Systems	9	79-230	Arab-Israeli Conflict and Peace Process since 1948	9
84-320	Domestic Politics and International Affairs	9	79-233	The United States and the Middle East since 1945	9
84-321	Autocrats and Democrats	9	79-235	Caribbean Cultures	9
84-322	Attitudes, the Media, and Conflict in International Relations	9	79-251	India/America: Democracy, Diversity, Development	9
84-323	War and Peace	9	79-255	Irish History	6
84-324	Democracies and War	9	79-257	Germany and the Second World War	9
84-362	Diplomacy and Statecraft	9	79-259	France During World War II	9
84-380	Grand Strategy in the United States	9	79-261	Chinese Culture and Society	9
84-386	The Privatization of Force	9	79-262	Modern China	9
84-389	Terrorism and Insurgency	9	79-264	Tibet in History and Imagination	9
84-393	Legislative Decision Making: U.S. Congress	9	79-265	Russian History: From the First to the Last Tsar	9
84-402	Judicial Politics and Behavior	9	79-266	Russian History: From Communism to Capitalism	9
84-414	International and Subnational Security	9	79-267	The Soviet Union in World War II: Military, Political, and Social History	9
88-223	Decision Analysis and Decision Support Systems	9	79-275	Introduction to Global Studies	9
88-281	Topics in Law: 1st Amendment	9	79-282	Europe and the World since 1800	9
88-284	Topics of Law: The Bill of Rights	9	79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
88-302	Behavioral Decision Making	9	79-299	Trafficking Persons: Children in a Global Context	9
88-388	Psychological Models of Decision Making	9	79-307	Religion and Politics in the Middle East	9
88-405	Risk Perception and Communication	9	79-312	International Human Rights Institutions in Theory and Practice	6
88-415	Global Competitiveness: Firms Nations, and Technological Change	9	79-314	The Politics and Culture of Memory	9
88-442	Decision Science in Intergroup Conflict	9	79-320	Women, Politics, and Protest	9
Economics and Society			79-338	History of Education in America	9
70-342	Managing Across Cultures	9	79-342	Introduction to Science and Technology Studies	9
70-365	International Trade and International Law	9	79-377	Food, Culture, and Power: A History of Eating	9
70-430	International Management	9	79-381	Energy and Empire: How Fossil Fuels Changed the World	9
73-148	Environmental Economics	9	79-383	Epidemics, Disease, and Public Health	9
73-328	Health Economics	12	79-385	The Making of the African Diaspora	9
73-331	Political Economy of Inequality and Redistribution	9	79-398	Documenting the 1967 Arab-Israeli War	9
73-372	International Money and Finance	9	82-304	The Francophone World	9
73-375	History of Money and Monetary Policy	9	82-320	Contemporary Society in Germany, Austria and Switzerland	9
73-394	Development Economics	9	82-323	Germany, Austria and Switzerland in the 20th Century	9
80-136	Social Structure, Public Policy & Ethics	9	82-333	Introduction to Chinese Language and Culture	Var.
80-244	Environmental Ethics	9	82-342	Spain: Language and Culture	9
80-247	Ethics and Global Economics	9	82-343	Latin America: Language and Culture	9
80-344	Management, Environment, and Ethics	9	82-344	U.S. Latinos: Language and Culture	9
80-348	Health Development and Human Rights	9	82-345	Introduction to Hispanic Literary and Cultural Studies	9
80-447	Global Justice	9	82-361	Italian Language and Culture I	9
84-310	International Political Economy and Organizations	9	82-362	Italian Language and Culture II	9
88-352	Environmental Economics and Policy	9	82-431	China and the West	9
88-378	International Economics	9	82-433	Topics in Contemporary Culture of China	9
88-391	Technology and Economic Growth	9			
88-410	The Global Economy: A User's Guide	9			
88-411	Rise of the Asian Economies	9			

82-441	Studies in Peninsular Literature and Culture	9
82-451	Studies in Latin American Literature and Culture	9
82-455	Topics in Hispanic Studies	9
82-474	Topics in Japanese Studies	9
82-541	Special Topics: Hispanic Studies	Var.
85-375	Crosscultural Psychology	9
300 or 400- level language course (at most one for this category)		

OR

Option 2) complete the majority of their electives via the Carnegie Mellon University Washington Semester Program (CMU/WSP) Public Policy elective sequence. Any elective units not fulfilled during CMU/WSP may be completed through coursework from the Grand Strategy and Political Institutions elective list.

The Washington Semester Program (CMUWSP) Public Policy Elective Sequence includes:

• Internship Seminar	12
• Policy Forum	12
• Core Seminar	12
• Elective Seminar	12

A list of CMU/WSP Core and Elective Seminars may be found in the CMU/WSP section of the undergraduate catalog (p. 282).

Japanese Studies Concentration (81 units minimum)

A BHA concentration in Japanese Studies promotes not just language proficiency but also an understanding of Japanese culture. Students who arrive at Carnegie Mellon with previous language study and/or who have high Advanced Placement, an International Baccalaureate, a Cambridge GCE Advanced level, or internal placement exam scores will be able to begin taking courses in the concentration earlier in their undergraduate program. In all cases, progress in the concentration will be accelerated by study abroad, which is recommended for all students.

Prerequisites

Low-intermediate level proficiency in Japanese. This is equivalent to the completion of three courses (two at the 100-level and one at the 200-level) or exemption based on internal placement test scores.

Core Courses in Japanese (36-39 units)

82-272	Intermediate Japanese II *	12
82-273	Introduction to Japanese Language and Culture	9
82-371	Advanced Japanese I	9
82-372	Advanced Japanese II	9

* Placement out of 82-272 is possible. For students who place out of 82-272, a minimum of 9 additional units must be taken from the Japanese Electives of the "Japanese Studies and Interdisciplinary Electives" category below.

Core Courses in Modern Languages (12 units)

Complete one 9 unit course plus the Senior Seminar (3 units).

82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
82-580	Senior Seminar in Modern Languages	3

Japanese Studies and Interdisciplinary Electives (33 units minimum)

Complete three courses from Japanese Electives and one course from Interdisciplinary Electives, or a minimum of two courses from Japanese Electives and two courses from Interdisciplinary Electives in consultation with the Japanese advisor. One course from Interdisciplinary Electives must be chosen from the History department courses, or with permission of the advisor students can instead complete at least one Japanese history course at the University of Pittsburgh (e.g., Modern Japan, Popular Religion in a Changing Japan, and Modern East Asia), one in Japan when they study abroad, or in a summer program at any other university.

Japanese Electives:

82-373	Structure of the Japanese Language	9
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82-374	Technical Japanese	9
82-473/474	Topics in Japanese Studies (Students may repeat with new topics.)	9
82-476	Japanese Discourse Analysis	9
82-505	Undergraduate Internship	Var.
82-571/572	Special Topics: Japanese Studies	Var.

Interdisciplinary Electives:

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and the advisor for the most up to date interdisciplinary electives appropriate for the Japanese Studies curriculum. Courses may be suggested to the advisor for approval as a substitute.

English		
76-239	Introduction to Film Studies	9
76-386	Language & Culture	9
76-387	Narrative & Argument	9

History		
79-211	East Asia in the World, 1600-Present	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-275	Introduction to Global Studies	9

Modern Languages

82-278	Japanese Film and Literature: The Art of Storytelling	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-358	Literacies Across Language and Culture	9
82-373	Structure of the Japanese Language	9
82-374	Technical Japanese	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9

Music

57-306	World Music	6
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Philosophy

80-180	Nature of Language	9
80-280	Linguistic Analysis	9
80-281	Language and Thought	9
80-380	Philosophy of Language	9

Psychology

85-375	Crosscultural Psychology	9
85-421	Language and Thought	9

Social and Decision Science

88-384	Conflict and Conflict Resolution in International Relations	9
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Linguistics Concentration (81 units minimum)

The BHA concentration in Linguistics combines courses from the departments of English, Modern Languages, Philosophy and Psychology and the Language Technologies Institute. Linguistics is the study of human language, and it encompasses a broad spectrum of research questions, approaches and methodologies. Some linguists are concerned with the cognitive aspects of language learning, production and comprehension; some are concerned with language as a social and cultural phenomenon; others engage in the analysis of linguistic form and meaning, some from a functional and others from a formal perspective. There are also computational approaches to linguistics with both applied and theoretical goals.

Introductory Course (1 course, 9 units)

80-180	Nature of Language	9
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Fundamental Skills Courses (2 courses, 18 units)

Take one course each in two of the following three areas:

Sounds:

80-282 Phonetics and Phonology I 9

Structure:

76-389 Rhetorical Grammar 9
80-280 Linguistic Analysis 9
80-285 Natural Language Syntax 9

Meaning:

76-385 Introduction to Discourse Analysis 9
80-381 Meaning in Language 9
80-383 Language in Use 9

Breadth Courses (2 courses, 18 units)

Take one course from each of the following two areas:

Language Learning and Language Cognition:

76-420 Process of Reading and Writing 9
82-280 Learning About Language Learning 9
82-383 Second Language Acquisition: Theories and Research 9
82-585 Topics in Second Language Acquisition 9
85-354 Infant Language Development 9
85-421 Language and Thought 9

Discourse, Society and Culture:

76-318 Communicating in the Global Marketplace 9
76-385 Introduction to Discourse Analysis 9
76-386 Language & Culture 9
82-273 Introduction to Japanese Language and Culture 9
82-305 French in its Social Contexts 9
82-311 Arabic Language and Culture I 9
82-312 Arabic Language and Culture II 9
82-333 Introduction to Chinese Language and Culture 9

Elective Courses (4 courses, 36 units)

Take four additional electives. These can be additional courses from the Fundamental Skills courses or Breadth courses listed above, or any other course which must be approved by the Director as a linguistics elective. Listed below are the additional electives taught on a regular basis. Additional appropriate courses are offered irregularly or on a one-off basis. The Director will provide students with a list of possible electives each semester, and will assist students in selecting electives which are consistent with their goals and interests. A list of these courses must be filed in the BXA office.

11-411 Natural Language Processing 12
11-716 Graduate Seminar on Dialog Processing 6
11-721 Grammars and Lexicons 12
11-722 Grammar Formalisms 12
11-761 Language and Statistics 12
11-762 Language and Statistics II 12
15-492 Special Topic: Speech Processing 12
76-373 Argument 9
76-378 Literacy: Educational Theory and Community Practice 9
76-451 Topics in Language Study 9
76-476 Rhetoric of Science 9
80-281 Language and Thought 9
80-283 Syntax and Discourse 9
80-284 Invented Languages 9
80-286 Words and Word Formation: Introduction to Morphology 9
80-287 Historical and Comparative Linguistics 9
80-380 Philosophy of Language 9
80-382 Phonetics and Phonology II 9
80-384 Linguistics of Turkic Languages 9
80-385 Linguistics of Germanic Languages 9
82-373 Structure of the Japanese Language 9
82-388 Understanding Second Language Fluency 9
82-442 Analysis of Spoken Spanish 9
82-444 The Structure of Spanish 9
82-476 Japanese Discourse Analysis 9

82-480 Social and Cognitive Aspects of Bilingualism 9

Language Requirement

Students must successfully complete two semesters of consecutive language courses. Students may not test out of this requirement. However, language courses taken at other institutions or as part of a study abroad program will typically substitute for a semester of language study.

Professional Writing Concentration (81 units minimum)

Professional Writing combines liberal and professional education with a strong foundation in rhetorical studies. The concentration in Professional Writing has a strong career orientation and is specifically designed to prepare students for successful careers as writers and communications specialists in a range of fields: publishing, government, journalism, the non-profit sector, education, public and media relations, corporate communications, advocacy writing, and the arts. The concentration is designed to develop articulate and reflective communications professionals with both the skills needed to enter and negotiate current work contexts (including writing for the web and other digital media) and the analytic and problem-solving skills needed to understand and keep pace with cultural and technological change.

Foundation Courses (4 courses, 36 units)

76-26x Survey of Forms (Nonfiction, Fiction, Poetry, or Screenwriting) 9
76-271 Introduction to Professional and Technical Writing 9
76-373 Argument 9
76-390 Style 9

Rhetoric/Language Studies Course (1 course, 9 units)

Students with a concentration in Professional Writing complete one course from designated Rhetoric courses offered and advertised each semester by the English Department. Rhetoric courses focus on understanding the role of language and language practices in both personal and professional contexts. Courses emphasize the relationships between texts and their contexts and pay particular attention to textual features, meaning, processes of reading and writing, and the ways in which language practices vary over time and across situations and cultures. The courses also equip students with explicit techniques for analyzing, understanding, and exploring language practices. The Rhetoric/Language Studies courses may also be taken as part of the concentration requirements for three additional, Advanced Writing/Rhetoric courses and include but are not limited to the following list.

76-319 Environmental Rhetoric 9
76-351 Rhetorical Invention 9
76-355 Leadership, Dialogue, and Change 9
76-373 Argument 9
76-386 Language & Culture 9
76-390 Style 9
76-396 Non-Profit Advocacy: Genres, Methods, and Issues 9
76-428 Visual Verbal Communication 9
76-476 Rhetoric of Science 9
76-484 Discourse Analysis 9
76-491 Rhetorical Analysis 9

Advanced Writing/Rhetoric Courses (3 courses, 27 units minimum)

Students with a concentration in Professional Writing complete three Advanced Writing/Rhetoric courses at the 300- or 400-level. Options for these courses include all of the Rhetoric/Language Studies courses listed above plus the writing-focused courses listed below. Additional courses that fulfill these requirements are advertised on a semester-by-semester basis. For help in choosing which of the possible options are most appropriate for various professional goals – journalism, writing for new media, editing and publishing, public relations/corporate communications, or science and technical writing – consult your English Department advisor and the “Selected Core Courses & Electives for PW Majors” advising sheet available through the English Department. All students with a concentration in PW, regardless of their career focus, are encouraged to take 76-391 Document & Information Design and 76-487 Web Design (in conjunction with the 3-unit 76-488 Web Design Lab) to extend their skills in writing for print to include information design for digital media. Both courses focus on the role of the writer in these specializations and provide lab instruction in the relevant software and related computer skills.

76-301 Internship Var.
76-302 Global Communication Center Practicum 9

76-319	Environmental Rhetoric	9
76-351	Rhetorical Invention	9
76-355	Leadership, Dialogue, and Change	9
76-372	News Writing	9
76-375	Magazine Writing	9
76-386	Language & Culture	9
76-389	Rhetorical Grammar	9
76-391	Document & Information Design	12
76-396	Non-Profit Advocacy: Genres, Methods, and Issues	9
76-428	Visual Verbal Communication	9
76-476	Rhetoric of Science	9
76-481	Writing for Multimedia	12
76-484	Discourse Analysis	9
76-487	Web Design	12
76-491	Rhetorical Analysis	9

English Elective (1 course, 9 units)

Students with a concentration in Professional Writing complete one additional course from the English Department's offerings. This course should be one that focuses on the relationships between texts and their cultural and historical contexts. Courses in literature, cultural studies, rhetoric, and media studies that meet this requirement are advertised on a semester-by-semester basis. The English Elective may be any course offered by the Department with the exception of 76-270 Writing for the Professions and 76-272 Language in Design, both of which are designed for non-majors and overlap with 76-271 Introduction to Professional and Technical Writing. Students with a concentration in PW are additionally encouraged to supplement their PW coursework with 76-300 Professional Seminar (3 units) to learn more about internship and career options in professional writing. 76-300 meets once per week and is offered every fall semester.

Psychology Concentration (81 units minimum)

Psychology is a science that embraces both biological and social sciences. It is a science concerned with establishing principles and laws regarding the ways in which people think, feel, and behave through the scientific study of human behavior. Students with a concentration in Psychology are expected not only to learn about findings already established by psychologists, but also to become proficient in the investigation and analysis of behavior. This includes observing behavior, formulating hypotheses, designing experiments to test these hypotheses, running experiments, performing statistical analyses, and writing reports.

Breadth Courses (4 courses, 36 units)

To gain familiarity with the breadth of the field of Psychology, students take 85-102 Introduction to Psychology and three survey courses.

Required Intro Course:

85-102	Introduction to Psychology	9
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Survey Courses:

85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	
85-219	Biological Foundations of Behavior	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9

Research Methods and Statistics (2 courses, 18 units)

Students complete one course in Research Methods (9 units). The corresponding survey course is a prerequisite for this course.

85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	9
85-330	Analytic Research Methods	9
85-340	Research Methods in Social Psychology	9

The following Statistics course is a prerequisite or co-requisite for all the Research Methods courses. This Statistics course counts toward the Psychology concentration.

36-309	Experimental Design for Behavioral and Social Sciences -Fall	9
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Advanced Courses (3 courses, 27 units)

Complete any three advanced courses or seminars in Psychology numbered higher than 85-341 (excepting 85-480, 85-482, 85-484, 85-505, 85-506, 85-507, 85-508).

Social & Political History Concentration (81 units minimum)

The BHA concentration in Social & Political History focuses on new ways to understand the past and new ways to use what we know, as well as on connections between past and present and on how historical knowledge facilitates understanding of social, cultural, and policy change. The History concentration emphasizes empirical methods and conceptual analysis, as well as specific research skills relevant to many types of jobs and further professional training. The History concentration combines a structured sequence of courses, training in research methods, theoretical concepts, and analytical writing skills, plus a considerable array of electives.

The BHA concentration in Social & Political History emphasizes broad-based, cumulative knowledge and interpretive skills in the study of the past. Offerings at the 200- and 300-level are designed to allow maximum flexibility in meeting requirements and maximum choice in focusing on particular themes, places, or eras. Upper-level courses aim to give students majoring in History more time together in smaller classes and more experience working with primary and secondary sources. The senior capstone seminar, Advanced Studies in History, provides training and experience in conducting original research and in interpretive, analytical writing—skills that prepare graduates for professional careers as well as for graduate or law school.

Options available in the following areas: 1) General Social & Political History, 2) US History 3) Regional or Non-US History

Required Courses for All Concentration Options (2 courses, 21 units)

79-200	Introduction to Historical Research -Sophomore or Junior year	9
79-420	Historical Research Seminar -Fall, Senior year	12

Work with History Advisor to Approve Concentration Option (60 units minimum):

General Social & Political History Required Courses (1 course, 9 units)

Required US Survey Course:

79-240	The Development of American Culture	9
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Choose one (9 units) Non-US Survey Course:

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-224	Mayan America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-233	The United States and the Middle East since 1945	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-255	Irish History	6
79-256	20th Century Germany	9
79-257	Germany and the Second World War	9
79-258	French History: From the Revolution to De Gaulle	9
79-259	France During World War II	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-267	The Soviet Union in World War II: Military, Political, and Social History	9

79-272 Iberian Encounters: Muslims, Christians, and Jews in Spain 9

A minimum of 42 additional History units must be approved with the History advisor. Any History courses not fulfilling another major requirement may be chosen as an elective.

US History Required Courses (1 course, 9 units)

Required US Survey Course:

79-240 The Development of American Culture 9

Choose one (9 units) Non-US Survey Course:

79-202 Flesh and Spirit: Early Modern Europe, 1400-1750 9

79-205 20th Century Europe 9

79-207 Development of European Culture 9

79-221 Development and Democracy in Latin America 9

79-222 Between Revolutions: The Development of Modern Latin America 9

79-224 Mayan America 9

79-225 West African History in Film 9

79-226 African History: Earliest Times to 1780 9

79-227 African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid 9

79-229 Origins of the Arab-Israeli Conflict, 1880-1948 9

79-230 Arab-Israeli Conflict and Peace Process since 1948 9

79-233 The United States and the Middle East since 1945 9

79-235 Caribbean Cultures 9

79-237 Comparative Slavery 9

79-251 India/America: Democracy, Diversity, Development 9

79-255 Irish History 6

79-256 20th Century Germany 9

79-257 Germany and the Second World War 9

79-258 French History: From the Revolution to De Gaulle 9

79-259 France During World War II 9

79-261 Chinese Culture and Society 9

79-262 Modern China 9

79-264 Tibet in History and Imagination 9

79-265 Russian History: From the First to the Last Tsar 9

79-266 Russian History: From Communism to Capitalism 9

79-267 The Soviet Union in World War II: Military, Political, and Social History 9

79-272 Iberian Encounters: Muslims, Christians, and Jews in Spain 9

Choose three (27 units) US History Courses:

79-231 American Foreign Policy: 1945-Present 9

79-233 The United States and the Middle East since 1945 9

79-241 African American History: Africa to the Civil War 9

79-242 African American History: Reconstruction to the Present 9

79-243 The Civil War in American Memory 6

79-244 Women in American History 9

79-245 Capitalism and Individualism in American Culture 9

79-246 Industrial America 9

79-247 The Civil War Era: 1848-1877 9

79-249 20th Century U.S. History 9

79-251 India/America: Democracy, Diversity, Development 9

79-252 Recent U.S. History, 1945-Present 9

79-288 Bananas, Baseball, and Borders: Latin America and the United States 9

79-300 History of American Public Policy 9

79-303 Pittsburgh and the Transformation of Modern Urban America 6

79-304 African Americans in Pittsburgh 6

79-315 Hawai'i: America's Pacific Island State 9

79-318 Sustainable Social Change: History and Practice 6

79-320 Women, Politics, and Protest 9

79-328 Photographers and Photography Since World War II 9

79-330 Medicine and Society 9

79-331 Body Politics: Women and Health in America 9

79-339 Juvenile Delinquency and Film (1920 to "The Wire") 9

79-340 Juvenile Delinquency and Juvenile Justice 9

79-342 Introduction to Science and Technology Studies 9

79-343 History of American Urban Life 9

79-345 The Roots of Rock and Roll 9

79-346 American Political Humor 9

79-348 Abraham Lincoln at 200 9

79-357 History of Black American Music 6

79-371 African American Urban History 9

79-372 Perspectives on the Urban Environment 9

79-374 American Environmental History: Critical Issues 9

79-383 Epidemics, Disease, and Public Health 9

79-395 The Arts in Pittsburgh 9

A minimum of 15 additional History units must be approved with the History advisor. Any History courses not fulfilling another major requirement may be chosen as an elective.

Regional or Non-US History Required Courses (2 courses, 18 units)

Choose two (18 units) Required Survey Courses:

79-202 Flesh and Spirit: Early Modern Europe, 1400-1750 9

79-203 Social and Political Change in 20th Century Central and Eastern Europe 9

79-205 20th Century Europe 9

79-207 Development of European Culture 9

79-221 Development and Democracy in Latin America 9

79-222 Between Revolutions: The Development of Modern Latin America 9

79-224 Mayan America 9

79-225 West African History in Film 9

79-226 African History: Earliest Times to 1780 9

79-227 African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid 9

79-229 Origins of the Arab-Israeli Conflict, 1880-1948 9

79-230 Arab-Israeli Conflict and Peace Process since 1948 9

79-233 The United States and the Middle East since 1945 9

79-240 The Development of American Culture 9

79-251 India/America: Democracy, Diversity, Development 9

79-255 Irish History 6

79-256 20th Century Germany 9

79-258 French History: From the Revolution to De Gaulle 9

79-261 Chinese Culture and Society 9

79-262 Modern China 9

79-264 Tibet in History and Imagination 9

79-265 Russian History: From the First to the Last Tsar 9

79-266 Russian History: From Communism to Capitalism 9

Choose three (27 units) Regional History Courses:

African Diaspora

79-222 Between Revolutions: The Development of Modern Latin America 9

79-225 West African History in Film 9

79-226 African History: Earliest Times to 1780 9

79-227 African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid 9

79-235 Caribbean Cultures 9

79-237 Comparative Slavery 9

79-241 African American History: Africa to the Civil War 9

79-242 African American History: Reconstruction to the Present 9

79-291 Globalization in East African History 6

79-295 Race Relations in the Atlantic World 9

79-304	African Americans in Pittsburgh	6
79-357	History of Black American Music	6
79-371	African American Urban History	9
79-385	The Making of the African Diaspora	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
East Asia		
79-251	India/America: Democracy, Diversity, Development	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-309	20th Century China Through Film	9
Europe		
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-255	Irish History	6
79-256	20th Century Germany	9
79-257	Germany and the Second World War	9
79-258	French History: From the Revolution to De Gaulle	9
79-259	France During World War II	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-323	Family, Gender, and Sexuality in European History, 500-1800	9
79-326	German History through Film	9
79-341	The Cold War in Documents and Film	9
79-352	Christendom Divided: The Protestant and Catholic Reformation, 1450-1650	9
79-353	Religious Identities and Religious Conflicts in 19th Century Europe	9
79-362	Law and Disorder in Early Modern Europe, 1400-1800	9
79-389	Stalin and Stalinism	9
Latin America		
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-224	Mayan America	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-254	The Jewish Diaspora in Latin America	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-295	Race Relations in the Atlantic World	9
Middle East		
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-233	The United States and the Middle East since 1945	9
79-307	Religion and Politics in the Middle East	9
79-398	Documenting the 1967 Arab-Israeli War	9
Russia and the Former Soviet States		
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-341	The Cold War in Documents and Film	9
79-389	Stalin and Stalinism	9

A minimum of 15 additional History units must be approved with the History advisor. Any History courses not fulfilling another major requirement may be chosen as an elective.

III. College of Fine Arts Concentration

(number of courses vary, 108 units minimum)

BHA students choose one of the following concentrations:

- Architecture (108 units)
- Art (108 units)
- Design (108 units)
- Drama (108 units)
- Music (108 units)

Architecture Concentration (108 units minimum)

Architecture Required Courses (52 units minimum)

48-100	Architecture Design Studio: Foundation I -Fall, Freshman year	10-12
or 48-095	Spatial Concepts for Non-Architects I	
48-120	Digital Media I -Fall, Freshman year	6
48-121	Analog Media I -Fall, Freshman year	6
48-125	Digital Media II -Spring, Freshman year	6
48-126	Analog Media II -Spring, Freshman year	6
48-240	Historical Survey of World Architecture and Urbanism I -Spring, Freshman year	9
48-241	Modern Architecture -Fall, Sophomore year	9

Architecture Electives (56 units minimum)

A minimum of 56 additional Architecture units must be approved by the Architecture advisor. A list of these selected courses must be filed in the BXA office.

Art Concentration (108 units minimum)

PORTFOLIO REVIEW REQUIRED FOR ADMISSION

Concept Studios (2 courses, 20 units)

Complete two courses:

60-101	Concept Studio: The Self and the Human Being	10
60-201	Concept Studio: Space and Time	10
60-202	Concept Studio: Systems and Processes	10
60-203	Concept Studio: EcoArt	10
60-204	Concept Studio: Networked Narrative	10

Media Studios (3 courses, 30 units)

Complete three courses:

60-150	2D Media Studio: Drawing	10
60-160	2D Media Studio: Imaging	10
60-250	2D Media Studio: Painting	10
60-251	2D Media Studio: Print Media	10
60-130-60-130	3-D Media Studio I-I (complete two minis, 5 units each)	10
60-131-60-131	3D Media Studio II-II (complete two minis, 5 units each)	10
60-110	Electronic Media Studio: Introduction to the Moving Image	10
60-210	Electronic Media Studio: Introduction to Interactivity	10

Advanced Studios (4 courses, 40 units)

Complete four courses. Courses may be offered in the fall and/or spring. Students may take courses in any media area (ETB, SIS, CP or DP3). They may take all courses in one media area if a focus is desired.

60-401/402	Senior Studio	10
60-403	Extended Studio	10
60-410 - 60-429	Advanced Electronic and Time-Based Work (ETB)	10
60-430 - 60-447	Advanced Sculpture, Installation and Site-Work (SIS)	10
60-448 - 60-449	Advanced Contextual Practice (CP)	10
60-450 - 60-498	Advanced Drawing, Painting, Print Media and Photography (DP3)	10
60-499	Studio Independent Study (one only)	10

Art History/Theory (2 courses, 18 units)

60-205	Modern Visual Culture 1789-1960 -Fall	9
60-206	Contemporary Visual Culture 1960 - Present - Spring	9

Review Requirement (complete 2 required reviews, 0 units)

A review is required at the end of the sophomore and senior years. Pass/no pass only.

60-200	Sophomore Review -Spring	0
60-400	Senior Review -Fall	0

Design Concentration (108 units minimum)

PORTFOLIO REVIEW REQUIRED FOR ADMISSION

Design Required Courses (96 units)

51-101	Studio: Survey of Design -Fall, Freshman year	9
51-103	Design Workshop I -Fall, Freshman year	3
51-121	Visualizing -Fall, Freshman year	9
51-171	Placing -Fall, Freshman year	9
51-102	Design Lab -Spring, Freshman year	9
51-104	Design Workshop II -Spring, Freshman year	3
51-122	Collaborative Visualizing -Spring, Freshman year	9
51-172	Systems -Spring, Freshman year	9

Choose Two Studios:

51-225	Communications Studio I: Understanding Form & Context -Fall, Sophomore year	4.5, 4.5
or 51-245	Products Studio I: Understanding Form & Context	
or 51-265	Environments Studio I: Understanding Form & Context	

Choose Two Corresponding Labs:

51-227	Prototyping Lab I: Communications -Fall, Sophomore year	4.5, 4.5
or 51-247	Prototyping Lab I: Products	
or 51-267	Prototyping Lab I: Environments	
51-271	How People Work -Fall, Sophomore year	9
51-371	Futures -Fall, Junior year or later	9

Design Electives (12 units minimum)

A minimum of 12 additional Design units must be approved by the Design advisor. A list of these selected courses must be filed in the BXA office.

Drama Concentration (108 units minimum)

AUDITION/INTERVIEW REQUIRED FOR DIRECTING OR DRAMATURGY CONCENTRATION OPTION. PORTFOLIO REVIEW/INTERVIEW REQUIRED FOR DESIGN OR PRODUCTION TECHNOLOGY AND MANAGEMENT CONCENTRATION OPTION.

Options available in the following areas: 1) Design, 2) Directing, 3) Dramaturgy, 4) Production Technology & Management

There is no BHA Acting or Musical Theatre option.

Required Courses for All Concentration Options (20 units)

54-175-54-176	Conservatory Hour-Conservatory Hour (1 unit each)	2
54-177	Foundations of Drama I	6
or 54-178	Foundations of Drama I	
54-281	Foundations of Drama II (prerequisite: 54-177 or 54-178)	6
or 54-282	Foundations of Drama II	
54-381	Special Topics in Drama: History, Literature and Criticism	6

Work with Drama Faculty Option Coordinator to Approve Concentration Option (88 units minimum):

Design Required Courses (26 units)

54-151-54-152	Stagecraft-Stagecraft (15 units + 11 units)	26
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A minimum of 62 additional Design units must be approved by the Design faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Directing Required Courses (52 units)

54-121-54-122	Directing I: Sources-Directing I: Sources	18
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54-221-54-222	Directing II: Fundamentals-Directing II: Fundamentals	18
54-159-54-160	Production Symposium I-I	12
54-517-54-518	Director's Colloquium-Director's Colloquium (four times, 4 units total)	2

A minimum of 36 additional Directing units must be approved by the Directing faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Dramaturgy Required Courses (53 units minimum)

54-109	Dramaturgy 1: Approaches to Text	9
54-184	Dramaturgy 2: Introduction to Production Dramaturgy	9
54-121	Directing I: Sources	9
54-160	Production Symposium I -Spring	6
54-200-54-200	Dramaturgy Forum-Dramaturgy Forum -Fall (minimum of two; every semester it is offered while enrolled)	2
54-xxx	Dramaturgy 3, 4, 5 or 6 (minimum of two; all four if enrolled as BXA for six semesters or more)	18

A minimum of 35 additional Dramaturgy units must be approved by the Dramaturgy faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Production Technology and Management Required Courses (26 units)

54-151-54-152	Stagecraft-Stagecraft (15 units + 11 units)	26
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A minimum of 62 additional PTM units must be approved by the PTM faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Music Concentration (108 units minimum)

AUDITION REQUIRED FOR PERFORMANCE CONCENTRATION OPTION. PORTFOLIO REVIEW/INTERVIEW REQUIRED FOR COMPOSITION, MUSICOLOGY, OR MUSIC TECHNOLOGY CONCENTRATION OPTION.

Options available in the following areas: 1) Performance (instrumental, piano, organ, voice), 2) Composition 3) Musicology, 4) Music Technology

Required Course for All Concentration Options (9 units)

57-152	Harmony I -Fall	9
or 57-149	Basic Harmony I	

Work with Music Advisor to Approve Concentration Option (99 units minimum):

Performance and Composition Required Courses (76 units)

57-161	Eurhythmics I -Fall (recommended co-requisite: 57-181)	3
57-181	Solfège I -Fall	3
or 57-180	Basic Solfège I	
or 57-185	Advanced Solfège I	
57-173	Survey of Western Music History -Fall (co-requisite: 57-188)	9
57-188	Repertoire and Listening for Musicians	1
57-69x	BXA Studio (4 semesters)	36
57-xxx	Major Ensemble (4 semesters)	24

A minimum of 23 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

Musicology Required Courses (45 units)

57-283	Music History I (co-requisite: 57-190)	9
57-284	Music History II (co-requisite: 57-289)	9
57-285	Music History III (co-requisite: 57-290)	9
57-189	Introduction to Repertoire and Listening for Musicians	3
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-611	Independent Study in History	6

Choose 36 units from:

57-209	The Beatles	9
57-306	World Music	6
57-412	Opera Since Wagner	9
57-414	Music and Nature	9
57-415	Mozart Operas	6
57-477	Music of the Spirit	6
57-478	Survey of Historical Recording	6
57-480	History of Black American Music	6

Graduate Musicology courses may be taken with instructor permission.

A minimum of 18 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

Music Technology Required Courses (40 units)

57-101	Introduction to Music Technology	6
57-181	Solfege I -Fall	3
or 57-180	Basic Solfege I	
or 57-185	Advanced Solfege I	
57-173	Survey of Western Music History -Fall (co-requisite: 57-188)	9
57-188	Repertoire and Listening for Musicians	1
57-337	Sound Recording	6
57-347	Electronic and Computer Music	6
57-xxx	Independent Study in Music Technology or Sound Recording	9

Choose 36 units from:

33-114	Physics of Musical Sound	9
57-153	Harmony II -Spring	9
57-182	Solfege II -Spring	3
or 57-186	Advanced Solfege II	
57-283	Music History I (co-requisite: 57-190)	9
57-284	Music History II (co-requisite: 57-289)	9
57-285	Music History III (co-requisite: 57-290)	9
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-338	Sound Editing and Mastering	6
57-345	Hacking the Music World	9
57-438	Multitrack Recording	9
60-131	3D Media Studio II	5
60-210	Electronic Media Studio: Introduction to Interactivity	10

A minimum of 23 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

IV. Free Electives

(approximately 9 courses, 78 units)

Take any Carnegie Mellon course. Many BHA students use their electives to broaden or deepen their concentrations. A maximum of 9 units of physical education and/or military science may be counted toward this requirement. Physical education and military science courses will not be calculated in a student's QPA.

Bachelor of Science and Arts Degree Program

Carnegie Mellon University recognizes that there are students who are naturally gifted in both the fine arts and the natural sciences or mathematics. In order to accommodate students who want to pursue an education simultaneously in these areas, we offer a degree that combines the strengths of the College of Fine Arts (CFA) and the Mellon College of Science (MCS). The intercollege degree, called the Bachelor of Science and Arts (BSA), is a rigorous program that offers a unique group of qualified

students the opportunity to develop their talents and interests in an area of the fine arts and an area of the natural sciences or mathematics.

The BSA curriculum is divided into three parts: 1) BSA General Education coursework, 2) CFA concentration coursework, and 3) MCS concentration coursework.

Students choose their fine arts concentration from among the five schools in CFA: Architecture, Art, Design, Drama or Music. A student must meet the entry requirements for the particular CFA school of their choice. While in the BSA Program, a student may change their CFA concentration only if they pass all admission requirements for that particular school.

Students choose their science concentration from among the four departments in MCS: Biological Sciences, Chemistry, Mathematical Sciences, Neurobiology, or Physics.

The BSA Degree Program is governed by faculty and administrators from both colleges and led by the director of the BXA Intercollege Degree Programs. The director and associate director of the BXA Intercollege Degree Programs are the primary advisors and liaisons between CFA and MCS. Students receive extensive advising support. Each student has two additional academic advisors: an advisor in the admitting school of CFA for their fine arts concentration, and an advisor in MCS for their natural sciences/mathematics concentration. This network of advisors guides each student through their curriculum.

BSA Curriculum

	Units
I. BSA General Education	129
II. MCS Concentration	114-134
III. CFA Concentration	108
IV. Free Electives	9-29
Total BSA Degree Requirements	380

I. BSA General Education

(18 courses, 129 units minimum)

- Mathematics (2 courses, 20 units, 21-120 and 21-122 or 21-124 required)
- Science (3 courses, 31 units, 03-121, 09-105, and 33-111 required)
- First-year Courses (2 courses, 12 units, 76-101 and 99-101 or 99-102 required)
- ENGAGE (3 courses, 3 units)
- Cultural/Global Understanding (1 course, 9 units)
- Humanities and Social Sciences (2 courses, 18 units)
- BXA Required Courses (5 courses, 36 units minimum, 52-190 and/or 52-291, 52-391, 52-392, 52-401, 52-402)

Technical Breadth Requirements (5 courses, 51 units)

As a 21st Century practicing scientist or mathematician, our graduates will work with others from a variety of technical backgrounds. Therefore, all of our students will be broadly trained within the technical fields of science and math. Students will fulfill this training by completing five (5) introductory technical courses in the Mellon College of Science at Carnegie Mellon University.

A student must take the five (5) courses listed below. AP/IB/Cambridge credit may be used to fulfill some of these requirements, but STEM electives must be taken at CMU or at another university for transfer credit to reach the total of five (5) Technical Breadth courses. A list of STEM electives can be found in the MCS general education requirements (p. 309).

Mathematics (2 courses, 20 units)

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	

Science (3 courses, 31 units)

03-121	Modern Biology	9
09-105	Introduction to Modern Chemistry I	10
33-121	Physics I for Science Students	12

Nontechnical Breadth Requirements (8 courses, 42 units)

MCS aspires for all of our undergraduates to leave our campus with a strong sense of personal integrity, social responsibility, ethics, working with

diverse others, global engagement, and personal health and well-being. The following non-technical breadth requirements will require students to develop a personalized plan for their course selection and meta-curricular participation to maximize their CMU experience. Our graduates will be well trained to be life-long and life-wide learners that will lead the scientific community and the world at large.

All candidates for BSA degree must complete the following non-technical breadth requirements:

First-year Courses (2 courses, 12 units)

76-101	Interpretation and Argument (various topics by section) www.cmu.edu/hss/english/first_year/index.html	9
99-101 or 99-102	Computing @ Carnegie Mellon Computing @ Carnegie Mellon	3

ENGAGE (3 courses, 3 units)

The ENGAGE courses are self-directed learning opportunities (using the MyCORE online platform) designed to enhance students' engagement with wellness and community service. Choose three courses from the list below:

38-110	ENGAGE in Service	1
38-230	ENGAGE in Wellness: Looking Inward	1
38-330	ENGAGE in Wellness: Looking Outward	1
38-430	ENGAGE in Wellness: Looking Forward	1

Cultural/Global Understanding (1 course, 9 units)

Cultural or global understanding course(s) may be taken at any time. Nine (9) or more units from the following group of courses will fulfill this requirement. Any student who finds an appropriate Carnegie Mellon course not on the list below that might fulfill this requirement should contact their academic advisor to review the course description to determine if it can be substituted. Cultural and global understanding courses that are taken while studying abroad can be used to fulfill this category. In addition, transfer courses will also be considered for this category.

57-173	Survey of Western Music History	9
57-209	The Beatles	9
57-306	World Music	6
70-342	Managing Across Cultures	9
73-331	Political Economy of Inequality and Redistribution	9
76-221	Books You Should Have Read By Now	9
76-227	Comedy	9
76-232	Introduction to African American Literature	9
76-239	Introduction to Film Studies	9
76-241	Introduction to Gender Studies	9
76-386	Language & Culture	9
79-104	Global Histories	9
79-201	Introduction to Anthropology	9
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-240	The Development of American Culture	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-255	Irish History	6
79-261	Chinese Culture and Society	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-275	Introduction to Global Studies	9
79-281	Introduction to Religion	9
79-297	Dilemmas and Controversies in Anthropology	9
79-307	Religion and Politics in the Middle East	9
79-345	The Roots of Rock and Roll	9
79-349	The Holocaust in Historical Perspective	9
79-350	Early Christianity	9

79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-357	History of Black American Music	6
79-377	Food, Culture, and Power: A History of Eating	9
80-100	Introduction to Philosophy	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-276	Philosophy of Religion	9
82-xxx	Any course from Modern Languages	9
99-241	Revolutions of Circularity	9
99-3xx	Any of the Country Today courses	9

Humanities and Social Sciences (2 courses, 18 units)

To fulfill this requirement, students must complete a minimum of two (2) nontechnical courses totaling at least 18 units in the Tepper School of Business and/or the Dietrich College of Humanities and Social Sciences. Courses counted toward the Cultural/Global Understanding requirement, and 76-101, do not count toward this requirement.

Check our web site for courses from DC, CFA, and Tepper that may NOT be used (<http://www.cmu.edu/mcs/undergrad/advising/hss-finearts/deletions.html>) to satisfy this requirement because they are too technical in nature, plus a list of courses in other colleges (including SCS, CIT, Tepper, and Heinz College) that do satisfy (<http://www.cmu.edu/mcs/undergrad/advising/hss-finearts/additions.html>) this requirement.

BXA Required Courses (5 courses, 36 units minimum)

BXA-specific courses give students the opportunity to integrate their areas of concentration by focusing on interdisciplinary approaches and arts-based research techniques.

52-190	BXA Seminar I: Building the Wunderkammer	9
or 52-291	BXA Seminar II: Building BXA	
52-391	BXA Junior Portfolio	0
52-392	BXA Seminar III: Deconstructing Disciplines	9
52-401	BXA Seminar IV: Capstone Fall	9
52-402	BXA Seminar V: Capstone Spring	9

II. Mellon College of Science Concentration

(number of courses vary, 114-134 units)

BSA students choose one of the following concentrations:

- Biological Sciences (117 units)
- Chemistry (121 units)
- Mathematical Sciences (122 units)
- Neurobiology (114 units)
- Physics (134 units)

Biological Sciences Concentration (117 units minimum)

Biological Sciences Required Courses (99 units minimum)

03-231	Biochemistry I	9
or 03-232	Biochemistry I	
03-240	Cell Biology	9
03-330	Genetics	9
03-124	Modern Biology Laboratory	9
or 03-343	Experimental Techniques in Molecular Biology	
03-201/202	Undergraduate Colloquium for Sophomores	2
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
09-218	Organic Chemistry II	9
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis*	12
or 03-344	Experimental Biochemistry	
or 03-345	Experimental Cell and Developmental Biology	
or 03-346	Experimental Neuroscience	
33-122	Physics II for Biological Sciences and Chemistry Students	9

* Students must complete 03-343 if they wish to take 03-344/5/6.

Biological Sciences Electives (2 courses, 18 units)

One course must be an advanced elective selected from 03-3xx or higher, excluding 03-445.

Chemistry Concentration (121 units minimum)

Chemistry Required Courses (103 units)

09-106	Modern Chemistry II	10
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10
09-214	Physical Chemistry	9
or 09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	
or 09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
09-204	Professional Communication Skills in Chemistry	3
09-201-09-202	Undergraduate Seminar I - Undergraduate Seminar II: Safety and Environmental Issues for Chemists - Undergraduate Seminar III	3
09-402	Undergraduate Seminar VI	3
33-122	Physics II for Biological Sciences and Chemistry Students	9

Advanced Chemistry Electives (2 courses, 18 units)

May be any upper level chemistry course, 09-3xx or higher, or Biochemistry I, 03-231 or 03-232, with the exception of 09-435 Independent Study, which can be used only by permission of the Director of Undergraduate Studies.

Mathematical Sciences Concentration (122 units minimum)

Mathematical Sciences Required Courses (86 units minimum)

(Reasonable substitutions within the core program will be allowed.)

15-110	Principles of Computing	10
21-127	Concepts of Mathematics (prerequisite for 15-211)	10
21-228	Discrete Mathematics	9
21-241	Matrices and Linear Transformations	10
or 21-341	Linear Algebra	
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
or 33-231	Physical Analysis	
21-355	Principles of Real Analysis I	9
21-373	Algebraic Structures	9
33-142	Physics II for Engineering and Physics Students	12
or 33-152	Matter and Interactions II	

Mathematical Sciences Electives (2 courses, 18 units)

Students with a music focus should take 21-372 Partial Differential Equations and Fourier Analysis.

Mathematical Sciences, Statistics, or Computer Science Electives (2 courses, 18 units)

May be computer science course above the 100-level, mathematical science courses beyond the calculus sequence, and statistics courses at the level of 36-225 or higher.

Neurobiology Concentration (114 units minimum)

Neurobiology Required Courses (12 courses, 96 units)

03-362	Cellular Neuroscience	9
09-217	Organic Chemistry I	9
33-122	Physics II for Biological Sciences and Chemistry Students	9
85-211	Cognitive Psychology	9
85-219	Biological Foundations of Behavior	9
or 03-161	Molecules to Mind	
03-363	Systems Neuroscience	9

03-201	Undergraduate Colloquium for Sophomores	2
03-231	Biochemistry I	9
03-240	Cell Biology	9
03-330	Genetics	9
03-342	Introduction to Biological Laboratory Practices	1
03-343	Experimental Techniques in Molecular Biology	12

Neurobiology Electives (2 courses, 18 units)

One course must be an advanced elective selected from 03-3xx or higher.

Physics Concentration (134 units minimum)

Physics Required Courses (116 units)

21-259	Calculus in Three Dimensions	9
33-104	Experimental Physics	9
33-142	Physics II for Engineering and Physics Students	12
or 33-152	Matter and Interactions II	
33-201	Physics Sophomore Colloquium I -Fall	2
33-202	Physics Sophomore Colloquium II -Spring	2
33-211	Physics III: Modern Essentials	10
33-228	Electronics I	10
33-231	Physical Analysis	10
33-232	Mathematical Methods of Physics	10
33-234	Quantum Physics	10
33-301	Physics Upperclass Colloquium I -Fall	1
33-302	Physics Upperclass Colloquium II -Spring	1
33-331	Physical Mechanics I	10
33-338	Intermediate Electricity and Magnetism I	10
33-340	Modern Physics Laboratory	10
33-341	Thermal Physics I	10

Physics Electives (2 courses, 18 units)

Two courses to be pre-approved by the Physics Department.

33-xxx	Two Physics Electives	18
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Note: 33-114 Physics of Musical Sound (9 units) is highly recommended for students with a Music concentration.

III. College of Fine Arts Concentration

(number of courses vary, 108 units minimum)

BSA students choose one of the following concentrations:

- Architecture (108 units)
- Art (108 units)
- Design (108 units)
- Drama (108 units)
- Music (108 units)

Architecture Concentration (108 units minimum)

Architecture Required Courses (52 units minimum)

48-100	Architecture Design Studio: Foundation I-Fall, Freshman year	10-12
or 48-095	Spatial Concepts for Non-Architects I	
48-120	Digital Media I-Fall, Freshman year	6
48-121	Analog Media I -Fall, Freshman year	6
48-125	Digital Media II -Spring, Freshman year	6
48-126	Analog Media II -Spring, Freshman year	6
48-240	Historical Survey of World Architecture and Urbanism I -Spring, Freshman year	9
48-241	Modern Architecture -Fall, Sophomore year	9

Architecture Electives (56 units minimum)

A minimum of 56 additional Architecture units must be approved by the Architecture advisor. A list of these selected courses must be filed in the BXA office.

Art Concentration (108 units minimum)

PORTFOLIO REVIEW REQUIRED FOR ADMISSION

Concept Studios (2 courses, 20 units)

Complete two courses:

60-101	Concept Studio: The Self and the Human Being	10
60-201	Concept Studio: Space and Time	10
60-202	Concept Studio: Systems and Processes	10
60-203	Concept Studio: EcoArt	10
60-204	Concept Studio: Networked Narrative	10

Media Studios (3 courses, 30 units)

Complete three courses:

60-150	2D Media Studio: Drawing	10
60-160	2D Media Studio: Imaging	10
60-250	2D Media Studio: Painting	10
60-251	2D Media Studio: Print Media	10
60-130-60-130	3-D Media Studio I-I (complete two minis, 5 units each)	10
60-131-60-131	3D Media Studio II-II (complete two minis, 5 units each)	10
60-110	Electronic Media Studio: Introduction to the Moving Image	10
60-210	Electronic Media Studio: Introduction to Interactivity	10

Advanced Studios (4 courses, 40 units)

Complete four courses. Courses may be offered in the fall and/or spring. Students may take courses in any media area (ETB, SIS, CP or DP3). They may take all courses in one media area if a focus is desired.

60-401/402	Senior Studio	10
60-403	Extended Studio	10
60-410 - 60-429	Advanced Electronic and Time-Based Work (ETB)	10
60-430 - 60-447	Advanced Sculpture, Installation and Site-Work (SIS)	10
60-448 - 60-449	Advanced Contextual Practice (CP)	10
60-450 - 60-498	Advanced Drawing, Painting, Print Media and Photography (DP3)	10
60-499	Studio Independent Study (one only)	10

Art History/Theory (2 courses, 18 units)

60-205	Modern Visual Culture 1789-1960 -Fall	9
60-206	Contemporary Visual Culture 1960 - Present - Spring	9

Review Requirement (Complete 2 required reviews, 0 units)

A review is required at the end of the sophomore and senior years. Pass/no pass only.

60-200	Sophomore Review -Spring	0
60-400	Senior Review -Fall	0

Design Concentration (108 units minimum)

PORTFOLIO REVIEW REQUIRED FOR ADMISSION

Design Required Courses (96 units)

51-101	Studio: Survey of Design -Fall, Freshman year	9
51-103	Design Workshop I -Fall, Freshman year	3
51-121	Visualizing -Fall, Freshman year	9
51-171	Placing -Fall, Freshman year	9
51-102	Design Lab -Spring, Freshman year	9
51-104	Design Workshop II -Spring, Freshman year	3
51-122	Collaborative Visualizing -Spring, Freshman year	9
51-172	Systems -Spring, Freshman year	9

Choose Two Studios:

51-225	Communications Studio I: Understanding Form & Context -Fall, Sophomore year	4.5, 4.5
or 51-245	Products Studio I: Understanding Form & Context	
or 51-265	Environments Studio I: Understanding Form & Context	

Choose Two Corresponding Labs:

51-227	Prototyping Lab I: Communications -Fall, Sophomore year	4.5, 4.5
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or 51-247	Prototyping Lab I: Products	
or 51-267	Prototyping Lab I: Environments	
51-271	How People Work -Fall, Sophomore year	9
51-371	Futures -Fall, Junior year or later	9

Design Electives (12 units minimum)

A minimum of 12 additional Design units must be approved by the Design advisor. A list of these selected courses must be filed in the BXA office.

Drama Concentration (108 units minimum)

AUDITION/INTERVIEW REQUIRED FOR DIRECTING OR DRAMATURGY CONCENTRATION OPTION. PORTFOLIO REVIEW/INTERVIEW REQUIRED FOR DESIGN OR PRODUCTION TECHNOLOGY AND MANAGEMENT CONCENTRATION OPTION.

Options available in the following areas: 1) Design, 2) Directing, 3) Dramaturgy, 4) Production Technology and Management

There is no BSA Acting or Musical Theatre option.

Required Courses for All Concentration Options (20 units)

54-175-54-176	Conservatory Hour-Conservatory Hour (1 unit each)	2
54-177	Foundations of Drama I	6
or 54-178	Foundations of Drama I	
54-281	Foundations of Drama II (prerequisite: 54-177 or 54-178)	6
or 54-282	Foundations of Drama II	
54-381	Special Topics in Drama: History, Literature and Criticism	6

Work with Drama Faculty Option Coordinator to Approve Concentration Option (88 units minimum):

Design Required Courses (26 units)

54-151-54-152	Stagecraft-Stagecraft (15 units + 11 units)	26
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A minimum of 62 additional Design units must be approved by the Design faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Directing Required Courses (52 units)

54-121-54-122	Directing I: Sources-Directing I: Sources	18
54-221-54-222	Directing II: Fundamentals-Directing II: Fundamentals	18
54-159-54-160	Production Symposium I-I	12
54-517-54-518	Director's Colloquium-Director's Colloquium (four times, 4 units total)	2

A minimum of 36 additional Directing units must be approved by the Directing faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Dramaturgy Required Courses (53 units minimum)

54-109	Dramaturgy 1: Approaches to Text	9
54-184	Dramaturgy 2: Introduction to Production Dramaturgy	9
54-121	Directing I: Sources	9
54-160	Production Symposium I -Spring	6
54-200-54-200	Dramaturgy Forum-Dramaturgy Forum -Fall (minimum of two; every semester it is offered while enrolled)	2
54-xxx	Dramaturgy 3, 4, 5 or 6 (minimum of two; all four if enrolled as BXA for six semesters or more)	18

A minimum of 35 additional Dramaturgy units must be approved by the Dramaturgy faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Production Technology and Management Required Courses (26 units)

54-151-54-152	Stagecraft-Stagecraft (15 units + 11 units)	26
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A minimum of 62 additional PTM units must be approved by the PTM faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Music Concentration (108 units minimum)

AUDITION REQUIRED FOR PERFORMANCE CONCENTRATION OPTION.
PORTFOLIO REVIEW/INTERVIEW REQUIRED FOR COMPOSITION,
MUSICOLOGY, OR MUSIC TECHNOLOGY CONCENTRATION OPTION.

Options available in the following areas: 1) Performance (instrumental, piano, organ, voice), 2) Composition 3) Musicology, 4) Music Technology

Required Course for All Concentration Options (9 units)

57-152	Harmony I -Fall	9
or 57-149	Basic Harmony I	

Work with Music Advisor to Approve Concentration Option (99 units minimum):

Performance and Composition Required Courses (76 units)

57-161	Eurhythmics I -Fall (recommended co-requisite: 57-181)	3
57-181	Solfège I -Fall	3
or 57-180	Basic Solfège I	
or 57-185	Advanced Solfège I	
57-173	Survey of Western Music History -Fall (co-requisite: 57-188)	9
57-188	Repertoire and Listening for Musicians	1
57-69x	BXA Studio (4 semesters)	36
57-xxx	Major Ensemble (4 semesters)	24

A minimum of 23 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

Musicology Required Courses (45 units)

57-283	Music History I (co-requisite: 57-190)	9
57-284	Music History II (co-requisite: 57-289)	9
57-285	Music History III (co-requisite: 57-290)	9
57-189	Introduction to Repertoire and Listening for Musicians	3
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-611	Independent Study in History	6

Choose 36 units from:

57-209	The Beatles	9
57-306	World Music	6
57-412	Opera Since Wagner	9
57-414	Music and Nature	9
57-415	Mozart Operas	6
57-477	Music of the Spirit	6
57-478	Survey of Historical Recording	6
57-480	History of Black American Music	6

Graduate Musicology courses may be taken with instructor permission.

A minimum of 18 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

Music Technology Required Courses (40 units)

57-101	Introduction to Music Technology	6
57-181	Solfège I -Fall	3
or 57-180	Basic Solfège I	
or 57-185	Advanced Solfège I	
57-173	Survey of Western Music History -Fall (co-requisite: 57-188)	9
57-188	Repertoire and Listening for Musicians	1
57-337	Sound Recording	6
57-347	Electronic and Computer Music	6
57-xxx	Independent Study in Music Technology or Sound Recording	9

Choose 36 units from:

33-114	Physics of Musical Sound	9
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57-153	Harmony II -Spring	9
57-182	Solfège II -Spring	3
or 57-186	Advanced Solfège II	
57-283	Music History I (co-requisite: 57-190)	9
57-284	Music History II (co-requisite: 57-289)	9
57-285	Music History III (co-requisite: 57-290)	9
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-338	Sound Editing and Mastering	6
57-345	Hacking the Music World	9
57-438	Multitrack Recording	9
60-131	3D Media Studio II	5
60-210	Electronic Media Studio: Introduction to Interactivity	10

A minimum of 23 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

IV. Free Electives

(approximately 1-3 courses, 9-29 units)

Take any Carnegie Mellon course. A maximum of 9 units of physical education and/or military science may be counted toward this requirement. Physical education and military science courses will not be calculated in a student's QPA.

Bachelor of Computer Science and Arts Degree Program

Carnegie Mellon University recognizes that there are students who are naturally gifted in both the fine arts and computer science. In order to accommodate students who want to pursue an education simultaneously in these areas, we offer a degree that combines the strengths of the College of Fine Arts (CFA) and the School of Computer Science (SCS). The intercollege degree, called the Bachelor of Computer Science and Arts (BCSA), is a rigorous program that offers a unique group of qualified students the opportunity to develop their talents and interests in an area of the fine arts and computer science.

The BCSA curriculum is divided into three parts: 1) BCSA General Education coursework, 2) CFA concentration coursework, and 3) SCS concentration coursework.

Students choose their fine arts concentration from among the five schools in CFA: Architecture, Art, Design, Drama or Music. A student must meet the entry requirements for the particular CFA school of their choice. While in the BCSA Program, a student may change their CFA concentration only if they pass all admission requirements for that particular school.

The BCSA Degree Program is governed by faculty and administrators from both colleges and led by the director of the BXA Intercollege Degree Programs. The director and associate director of the BXA Intercollege Degree Programs are the primary advisors and liaisons between CFA and SCS. Students receive extensive advising support. Each student has two additional academic advisors: an advisor in the admitting school of CFA for their fine arts concentration, and an advisor in SCS for their computer science concentration. This network of advisors guides each student through their curriculum.

BCSA Curriculum

	Units
I. BCSA General Education	121
II. SCS Concentration	111
III. CFA Concentration	108-118
IV. Free Electives	30-40
Total BCSA Degree Requirements	380

I. BCSA General Education

(15 courses, 121 units minimum)

- Writing/Expression (1 course, 9 units, 76-101 required)
- Cultural Analysis (1 course, 9 units)
- Mathematics (2 courses, 20 units, 21-120 and either 21-122 or 21-241 required), Probability (1 course, 9 units minimum required)
- Science (2 courses, 18 units minimum)
- Engineering (In consultation with your academic advisor, an engineering course could substitute for one of the two Science requirements.)
- Economic, Political, & Social Institutions OR Cognition, Choice & Behavior (1 course, 9 units minimum)
- One additional course from one of the following departments: English, History, Modern Languages, Philosophy, or Psychology (1 course, 9 units minimum)
- Computing @ Carnegie Mellon (1 course, 3 units, 99-101 or 99-102 required)
- BXA Required Courses (5 courses, 36 units minimum, 52-190 and/or 52-291, 52-391, 52-392, 52-401, 52-402)

Writing (1 course, 9 units)

Broadly considered, language is a tool used to communicate, as well as a way to organize non-visual and non-mathematical thinking. This requirement focuses on the social nature of language and the ways in which writing constitutes thinking.

76-101	Interpretation and Argument	9
(various topics by section) www.cmu.edu/hss/english/first_year/index.html		

Cultural Analysis (1 course, complete 9 units)

This requirement seeks to recognize cultures that have shaped and continue to shape the human experience; courses in this category are usually either broad in place, time, or cultural diversity.

57-173	Survey of Western Music History *	9
70-342	Managing Across Cultures *	9
76-232	Introduction to African American Literature *	9
76-239	Introduction to Film Studies *	9
76-241	Introduction to Gender Studies *	9
79-104	Global Histories	9
79-207	Development of European Culture	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-226	African History: Earliest Times to 1780	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-240	The Development of American Culture	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-255	Irish History	6
79-262	Modern China	9
79-281	Introduction to Religion	9
79-282	Europe and the World since 1800	9
79-345	The Roots of Rock and Roll	9
79-350	Early Christianity	9
79-395	The Arts in Pittsburgh	9
79-396	Music and Society in 19th and 20th Century Europe and the U.S.	9
80-100	Introduction to Philosophy	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-276	Philosophy of Religion	9
82-273	Introduction to Japanese Language and Culture	9
82-293	Introduction to Russian Culture	9
82-303	Introduction to French Culture *	9
82-304	The Francophone World *	9

82-333	Introduction to Chinese Language and Culture *	Var.
82-342	Spain: Language and Culture *	9
82-343	Latin America: Language and Culture *	9
82-344	U.S. Latinos: Language and Culture *	9
82-345	Introduction to Hispanic Literary and Cultural Studies *	9

* Indicates co-requisites and/or prerequisites required.

Mathematics & Probability (3 courses, 29 units minimum)

Choose two mathematics courses (20 units):

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-241	Matrices and Linear Transformations	

Choose one probability course (9 units minimum):

15-359	Probability and Computing	12
21-325	Probability	9
36-217	Probability Theory and Random Processes	9
36-225	Introduction to Probability Theory	9

Science (2 courses, 18 units minimum)

Choose two courses from the following list:

03-121	Modern Biology	9
09-105	Introduction to Modern Chemistry I	10
21-259	Calculus in Three Dimensions	9
33-111	Physics I for Science Students	12

Engineering

In consultation with your academic advisor, an engineering course could substitute for one of the two Science requirements.

Economic, Political & Social Institutions OR Cognition, Choice & Behavior (1 course from either category, complete 9 units minimum)

Economic, Political & Social Institutions

This requirement explores the processes by which institutions organize individual preferences and actions into collective outcomes.

19-101	Introduction to Engineering and Public Policy *	12
36-303	Sampling, Survey and Society *	9
70-332	Business, Society and Ethics *	9
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics *	9
73-240	Intermediate Macroeconomics *	9
79-300	History of American Public Policy	9
79-320	Women, Politics, and Protest	9
79-331	Body Politics: Women and Health in America	9
80-135	Introduction to Political Philosophy	9
80-136	Social Structure, Public Policy & Ethics	9
80-235	Political Philosophy	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-341	Computers, Society and Ethics	9
84-104	Decision Processes in American Political Institutions	9
88-110	Experiments with Economic Principles	9
88-220	Policy Analysis I	9

* Indicates co-requisites and/or prerequisites required.

Cognition, Choice, and Behavior

This requirement explores the process of thinking, decision making, and behavior in the context of the individual.

70-311	Organizational Behavior *	9
80-130	Introduction to Ethics	9
80-150	Nature of Reason	9
80-180	Nature of Language	9
80-221	Philosophy of Social Science	9
80-230	Ethical Theory	9

80-241	Ethical Judgments in Professional Life	9
80-270	Philosophy of Mind	9
80-271	Philosophy and Psychology	9
80-275	Metaphysics	9
80-281	Language and Thought	9
85-102	Introduction to Psychology	9
85-211	Cognitive Psychology	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9
85-261	Abnormal Psychology	9
88-120	Reason, Passion and Cognition	9
88-260	Organizations	9

* Indicates co-requisites and/or prerequisites required.

Complete ONE additional course from one of the following departments (1 course, complete 9 units minimum)

- English
- History
- Modern Languages
- Philosophy
- Psychology

Computing @ Carnegie Mellon (1 course, 3 units)

This is a mini-course, pass/no pass, to be completed in the first semester.

99-101	Computing @ Carnegie Mellon -REQUIRED	3
or 99-102	Computing @ Carnegie Mellon	

BXA Required Courses (5 courses, 36 units minimum)

BXA-specific courses give students the opportunity to integrate their areas of concentration by focusing on interdisciplinary approaches and arts-based research techniques.

52-190	BXA Seminar I: Building the Wunderkammer	9
or 52-291	BXA Seminar II: Building BXA	
52-391	BXA Junior Portfolio	0
52-392	BXA Seminar III: Deconstructing Disciplines	9
52-401	BXA Seminar IV: Capstone Fall	9
52-402	BXA Seminar V: Capstone Spring	9

II. School of Computer Science Concentration

Computer Science Concentration (111 units minimum)

Prerequisite

15-112	Fundamentals of Programming and Computer Science	12
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Computer Science Core Requirements (56 units)

15-122	Principles of Imperative Computation	10
15-150	Principles of Functional Programming	10
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-213	Introduction to Computer Systems	12
15-251	Great Theoretical Ideas in Computer Science	12

Concepts of Mathematics (10 units)

21-127	Concepts of Mathematics (co-requisite for 15-122; prerequisite for 15-150)	10
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Applications Courses or CS Electives (5 courses, 45 units minimum)

Choose a minimum of five courses from SCS beyond the core requirements, 200-level or higher, not including 15-221, 15-351, 16-223, 08-200. Listed below are suggested choices for these electives. Consult with the CS advisor if interested in courses not listed.

05-331	Building Virtual Worlds (12 units for CS concentration, 12 units for Art concentration)	24
05-391	Designing Human Centered Software	12

11-411	Natural Language Processing	12
15-214	Principles of Software Construction: Objects, Design, and Concurrency	12
15-237	Special Topic: Cross-Platform Mobile Web Apps	12
15-322	Introduction to Computer Music	9
15-323	Computer Music Systems and Information Processing	9
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-415	Database Applications	12
15-437	Web Application Development	12
15-451	Algorithm Design and Analysis	12
15-462	Computer Graphics	12
15-463	Computational Photography	12
15-464	Technical Animation	12
15-465	Animation Art and Technology	12
15-466	Computer Game Programming	12
16-362	Mobile Robot Programming Laboratory	12
16-384	Robot Kinematics and Dynamics	12
16-385	Computer Vision	9

III. College of Fine Arts Concentration

(number of courses vary, 108-118 units minimum)

BCSA students choose one of the following concentrations:

- Architecture (108 units)
- Art (118 units)
- Design (108 units)
- Drama (108 units)
- Music (108 units)

Architecture Concentration (108 units minimum)

Architecture Required Courses (52 units minimum)

48-100	Architecture Design Studio: Foundation I -Fall, Freshman year	10-12
or 48-095	Spatial Concepts for Non-Architects I	
48-120	Digital Media I -Fall, Freshman year	6
48-121	Analog Media I -Fall, Freshman year	6
48-125	Digital Media II -Spring, Freshman year	6
48-126	Analog Media II -Spring, Freshman year	6
48-240	Historical Survey of World Architecture and Urbanism I -Spring, Freshman year	9
48-241	Modern Architecture -Fall, Sophomore year	9

Architecture Electives (56 units minimum)

A minimum of 56 additional Architecture units must be approved by the Architecture advisor. A list of these selected courses must be filed in the BXA office.

Art Concentration (118 units minimum)

PORTFOLIO REVIEW REQUIRED FOR ADMISSION

Concept Studios (2 courses, 20 units)

Complete two courses:

60-101	Concept Studio: The Self and the Human Being	10
60-201	Concept Studio: Space and Time	10
60-202	Concept Studio: Systems and Processes	10
60-203	Concept Studio: EcoArt	10
60-204	Concept Studio: Networked Narrative	10

Media Studios (2 courses, 20 units)

Complete two courses:

60-150	2D Media Studio: Drawing	10
60-160	2D Media Studio: Imaging	10
60-250	2D Media Studio: Painting	10
60-251	2D Media Studio: Print Media	10
60-130-60-130	3-D Media Studio I-I (complete two minis, 5 units each)	10

60-131-60-131	3D Media Studio II-II (complete two minis, 5 units each)	10
60-110	Electronic Media Studio: Introduction to the Moving Image	10
60-210	Electronic Media Studio: Introduction to Interactivity	10

Advanced Studios (6 courses, 60 units)

Complete six courses. Courses may be offered in the fall and/or spring. Students may take courses in any media area (ETB, SIS, CP or DP3). They may take all courses in one media area if a focus is desired.

60-401/402	Senior Studio	10
60-403	Extended Studio	10
60-410 - 60-429	Advanced Electronic and Time-Based Work (ETB)	10
60-430 - 60-447	Advanced Sculpture, Installation and Site-Work (SIS)	10
60-448 - 60-449	Advanced Contextual Practice (CP)	10
60-450 - 60-498	Advanced Drawing, Painting, Print Media and Photography (PDP)	10
60-499	Studio Independent Study (one only)	10

Art History/Theory (2 courses, 18 units)

60-205	Modern Visual Culture 1789-1960 -Fall	9
60-206	Contemporary Visual Culture 1960 - Present - Spring	9

Review Requirement (Complete 2 required reviews, 0 units)

A review is required at the end of the sophomore and senior years. Pass/no pass only.

60-200	Sophomore Review -Spring	0
60-400	Senior Review -Fall	0

Design Concentration (108 units minimum)

PORTFOLIO REVIEW REQUIRED FOR ADMISSION

Design Required Courses (96 units)

51-101	Studio: Survey of Design -Fall, Freshman year	9
51-103	Design Workshop I -Fall, Freshman year	3
51-121	Visualizing -Fall, Freshman year	9
51-171	Placing -Fall, Freshman year	9
51-102	Design Lab -Spring, Freshman year	9
51-104	Design Workshop II -Spring, Freshman year	3
51-122	Collaborative Visualizing -Spring, Freshman year	9
51-172	Systems -Spring, Freshman year	9

Choose Two Studios:

51-225	Communications Studio I: Understanding Form & Context -Fall, Sophomore year	4.5, 4.5
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or 51-245 Products Studio I: Understanding Form & Context
or 51-265 Environments Studio I: Understanding Form & Context

Choose Two Corresponding Labs:

51-227	Prototyping Lab I: Communications -Fall, Sophomore year	4.5, 4.5
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or 51-247	Prototyping Lab I: Products	
or 51-267	Prototyping Lab I: Environments	
51-271	How People Work -Fall, Sophomore year	9
51-371	Futures -Fall, Junior year or later	9

Design Electives (12 units minimum)

A minimum of 12 additional Design units must be approved by the Design advisor. A list of these selected courses must be filed in the BXA office.

Drama Concentration (108 units minimum)

AUDITION/INTERVIEW REQUIRED FOR DIRECTING OR DRAMATURGY CONCENTRATION OPTION. PORTFOLIO REVIEW/INTERVIEW REQUIRED FOR DESIGN OR PRODUCTION TECHNOLOGY AND MANAGEMENT CONCENTRATION OPTION.

Options available in the following areas: 1) Design, 2) Directing, 3) Dramaturgy, 4) Production Technology and Management
There is no BHA Acting or Musical Theatre option.

Required Courses for All Concentration Options (20 units)

54-175-54-176	Conservatory Hour-Conservatory Hour (1 unit each)	2
54-177	Foundations of Drama I	6
or 54-178	Foundations of Drama I	
54-281	Foundations of Drama II (prerequisite: 54-177 or 54-178)	6
or 54-282	Foundations of Drama II	
54-381	Special Topics in Drama: History, Literature and Criticism	6

Work with Drama Faculty Option Coordinator to Approve Concentration Option (88 units minimum):

Design Required Courses (26 units)

54-151-54-152	Stagecraft-Stagecraft (15 units + 11 units)	26
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A minimum of 62 additional Design units must be approved by the Design faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Directing Required Courses (52 units)

54-121-54-122	Directing I: Sources-Directing I: Sources	18
54-221-54-222	Directing II: Fundamentals-Directing II: Fundamentals	18
54-159-54-160	Production Symposium I-I	12
54-517-54-518	Director's Colloquium-Director's Colloquium (four times, 4 units total)	2

A minimum of 36 additional Directing units must be approved by the Directing faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Dramaturgy Required Courses (53 units minimum)

54-109	Dramaturgy 1: Approaches to Text	9
54-184	Dramaturgy 2: Introduction to Production Dramaturgy	9
54-121	Directing I: Sources	9
54-160	Production Symposium I -Spring	6
54-200-54-200	Dramaturgy Forum-Dramaturgy Forum -Fall (minimum of two; every semester it is offered while enrolled)	2
54-xxx	Dramaturgy 3, 4, 5 or 6 (minimum of two; all four if enrolled as BXA for six semesters or more)	18

A minimum of 35 additional Dramaturgy units must be approved by the Dramaturgy faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Production Technology and Management Required Courses (26 units)

54-151-54-152	Stagecraft-Stagecraft (15 units + 11 units)	26
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A minimum of 62 additional PTM units must be approved by the PTM faculty option coordinator. A list of these selected courses must be filed in the BXA office.

Music Concentration (108 units minimum)

AUDITION REQUIRED FOR PERFORMANCE CONCENTRATION OPTION. PORTFOLIO REVIEW/INTERVIEW REQUIRED FOR COMPOSITION, MUSICOLOGY, OR MUSIC TECHNOLOGY CONCENTRATION OPTION.

Options available in the following areas: 1) Performance (instrumental, piano, organ, voice), 2) Composition 3) Musicology, 4) Music Technology

Required Course for All Concentration Options (9 units)

57-152	Harmony I -Fall	9
or 57-149	Basic Harmony I	

Work with Music Advisor to Approve Concentration Option (99 units minimum):

Performance and Composition Required Courses (76 units)

57-161	Eurhythmics I -Fall (recommended co-requisite: 57-181)	3
57-181	Solfège I -Fall	3
or 57-180	Basic Solfège I	
or 57-185	Advanced Solfège I	

57-173	Survey of Western Music History -Fall (co-requisite: 57-188)	9
57-188	Repertoire and Listening for Musicians	1
57-69x	BXA Studio (4 semesters)	36
57-xxx	Major Ensemble (4 semesters)	24

A minimum of 23 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

Musicology Required Courses (45 units)

57-283	Music History I (co-requisite: 57-190)	9
57-284	Music History II (co-requisite: 57-289)	9
57-285	Music History III (co-requisite: 57-290)	9
57-189	Introduction to Repertoire and Listening for Musicians	3
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-611	Independent Study in History	6

Choose 36 units from:

57-209	The Beatles	9
57-306	World Music	6
57-412	Opera Since Wagner	9
57-414	Music and Nature	9
57-415	Mozart Operas	6
57-477	Music of the Spirit	6
57-478	Survey of Historical Recording	6
57-480	History of Black American Music	6

Graduate Musicology courses may be taken with instructor permission.

A minimum of 18 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

Music Technology Required Courses (40 units)

57-101	Introduction to Music Technology	6
57-181	Solfege I -Fall	3
or 57-180	Basic Solfege I	
or 57-185	Advanced Solfege I	
57-173	Survey of Western Music History -Fall (co-requisite: 57-188)	9
57-188	Repertoire and Listening for Musicians	1
57-337	Sound Recording	6
57-347	Electronic and Computer Music	6
57-xxx	Independent Study in Music Technology or Sound Recording	9

Choose 36 units from:

33-114	Physics of Musical Sound	9
57-153	Harmony II -Spring	9
57-182	Solfege II -Spring	3
or 57-186	Advanced Solfege II	
57-283	Music History I (co-requisite: 57-190)	9
57-284	Music History II (co-requisite: 57-289)	9
57-285	Music History III (co-requisite: 57-290)	9
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-338	Sound Editing and Mastering	6
57-345	Hacking the Music World	9
57-438	Multitrack Recording	9
60-131	3D Media Studio II	5
60-210	Electronic Media Studio: Introduction to Interactivity	10

A minimum of 23 additional Music units must be approved by the Music advisor. A list of these selected courses must be filed in the BXA office.

IV. Free Electives

(approximately 3-4 courses, 30-40 units minimum)

Take any Carnegie Mellon course. A maximum of 9 units of physical education and/or military science may be counted toward this requirement. Physical education and military science courses will not be calculated in a student's QPA.

College of Engineering

James H. Garrett, Jr., Dean and Thomas Lord Professor of Civil and Environmental Engineering
 Annette M. Jacobson, Associate Dean for Undergraduate Studies
 Kurt Larsen, Assistant Dean for Undergraduate Studies
 Office: Scaife Hall 110
<http://www.cit.cmu.edu/>

Carnegie Institute of Technology, the engineering college of the university, has three main activities - undergraduate education, graduate education, and research. Its continuing goal has been to maintain excellence in all these activities. The degree to which this goal has been achieved is attested to by the demand for its graduates, the success of its alumni, the quality of its students and faculty, the adoption elsewhere of its innovations, and the national and international recognition it receives in educational and research activities.

The college offers the degree of bachelor of science in chemical engineering, civil engineering, electrical and computer engineering, mechanical engineering, and materials science and engineering. All of these programs are accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

An engineering student may also choose to pursue a minor in one of the CIT designated minor programs, or a double major in engineering and public policy or biomedical engineering, or to design a minor, additional major or dual-degree programs with other non-engineering departments.

Educational Objectives

The overarching objective of our engineering curriculum is to provide our students an education that enables them to be productive and fulfilled professionals throughout their careers. Our more specific, measurable objectives for graduates of our engineering curriculum are the following:

- Graduates recognize that they acquired a high quality, rigorous technical education from the College of Engineering at Carnegie Mellon.
- Graduates, in addition to their technical knowledge, recognize that they have acquired a broader body of knowledge that allows them to understand the larger context of the problems that they must address during their career.
- Graduates use their technical foundation and their broader base of knowledge to be successful in a diverse collection of individual careers inside and outside of the engineering profession.

From its earliest days, Carnegie Institute of Technology (CIT) has considered undergraduate education to be the key element in the development of future leaders. In this regard, CIT has adopted a plan for education that is designed to equip students with the capacity to learn and to continue the process of self-education throughout their lives. The present curriculum incorporates this philosophy by providing the opportunity for both breadth in a number of engineering, science, humanities and fine arts areas as well as depth in a major area of concentration. To achieve these goals, our flexible curriculum has been designed to allow students to customize their program to suit their needs and to help each student acquire:

- A thorough and integrated understanding of fundamental knowledge in fields of a students' major interest and the ability to use this knowledge;
- Competence in the orderly way of thinking, which professionals and scientists have always used in reaching sound, creative conclusions, with the goal that after graduation the student can, by such thinking, reach decisions both as a professional and as a citizen;
- An ability to learn independently with scholarly orderliness, so that after graduation the student will be able to grow in wisdom and keep abreast of the changing knowledge and problems of the profession and the society in which he or she participates;
- The philosophical outlook, breadth of knowledge, and sense of values which will increase the student's understanding and enjoyment of life and enable each student to recognize and deal effectively with the human, economic, ethical and social aspects of professional problems; and
- The ability to communicate ideas to others in a comprehensive and understandable manner.

The curriculum encourages students to confront professional problems, accomplished through team and problem-oriented courses, as well as courses which emphasize design or individual projects. These classes stress creativity and independent thought and require the student to define the problem, propose a solution or a design in the presence of technical and

socioeconomic constraints, to make judgments among alternative solutions, and to explore innovative alternatives to more conventional solutions.

First Year for Engineering Students

The Carnegie Mellon engineering education is based on engineering and science fundamentals that give students the skills to face new and challenging situations. The first year in engineering provides a broad foundation upon which students build a curriculum in their eventual major.

Since students in CIT do not select a major until the end of the first year, all first year students share a common experience consisting of introductory courses in the engineering majors (one each semester), calculus, physics, other science courses which compliment specific introductory engineering courses, and courses in the College of Humanities and Social Sciences (General Education). This curriculum helps make an informed decision about a final major. Below is an examples of a standard schedule for a first-year engineering student.

Introductory Engineering Elective	12
Restricted Technical Elective	9-12
Differential and Integral Calculus	10
General Education ⁵	9
Computing @ Carnegie Mellon	3
Introductory Engineering Elective	12
Restricted Technical Elective	10
Integration, Differential Equations, Approximation	10
General Education Course ⁵	9

Notes:

1. Each semester every CIT department offers its Introductory Engineering Elective.* Every first year CIT student must select one such course each semester.
* Except 19-101, offered only in spring.
2. Each Introductory Engineering Elective requires a specific Restricted Technical Elective (as a pre- or co-requisite) as given below:

Introductory Engineering Course	Restricted Technical Elective
Biomedical Engineering	03-121
Chemical Engineering	09-105
Civil Environmental Engineering	33-106
Electrical Computer Engineering	15-110 or 15-112
Engineering Public Policy	33-106
Mechanical Engineering	33-106
Materials Science Engineering	33-106

3. Restricted Technical Electives include the following courses:

		Units
03-121	Modern Biology	9
09-105	Introduction to Modern Chemistry I	10
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
33-106	Physics I for Engineering Students	12

4. All students must complete 33-106 Physics I for Engineering Students by the end of the first year. Therefore, if a student chooses to take Introduction to Chemical Engineering (with 09-105 as a co-requisite) during one semester and Introduction to Electrical and Computer Engineering (with 15-110 as a co-requisite), the student must take 33-106 in place of the General Education requirement in the Spring semester of the first year and take the General Education course in a subsequent semester. Alternatively, a student entering the university with AP credit in a required first year course may substitute 33-106 in its place.
2. Interpretation and Argument, 76-101, should be completed in the first year. Some students for whom English is not a native language, may have to take 76-100 first.

Program in General Education for CIT Students for the Class of 2015 and earlier

27 Units Breadth Requirement

Humanistic Studies (Cultural Analysis)*	9 units
Cognitions and Institutions*	9 units
Writing/Expression **	9 units

* A list of acceptable courses for Humanistic Studies and Cognitions and Institutions is available at www.cit.cmu.edu in the General Education section.

** The Writing/Expression requirement consists of the following course: 76-101 Interpretation and Argument (9 units)

27 units Depth Sequence in Humanities, Social Science, or Fine Arts

A sequence of humanities, social science, or fine arts courses which provides depth in a specific area. Usually, 27 units from a single department meet this requirement. However, related courses from different departments may also satisfy this requirement. A depth sequence in language must include at least three nine-unit courses in the same language. Statistics Department courses may NOT be used to satisfy this requirement. Courses from Business Administration (70-xxx) and Heinz College that are on the above "Acceptable Non-DC/CFA courses for Non-Technical Electives" list can be used as part of a Depth Sequence. Although this requirement is typically satisfied by completing 3 courses of at least 9 units each, some acceptable courses are greater or less than 9 units (e.g. 6-unit Art courses). While mini courses of fewer than 9 units may be combined to equal 9 unit courses, the excess units from courses greater 9 units may NOT be used to satisfy this requirement. For example, a 12 unit, 6 unit, 9 unit combination is not acceptable. A 6 unit, 3 unit, 9 unit, 9 unit combination is acceptable.

18 units Non-Technical Electives

Two unrestricted humanities, social science or fine arts courses. Non-technical courses from Business Administration, or the Heinz College may also satisfy this requirement. Accounting, finance, management, marketing, production, and statistics courses are regarded as technical courses and may NOT be used to satisfy this requirement. Although this requirement is typically satisfied by completing 2 courses of at least 9 units each, some acceptable courses are greater or less than 9 units (e.g. 6-unit Art courses). While mini courses of fewer than 9 units may be combined to equal 9 unit courses, the excess units from courses greater 9 units may NOT be used to satisfy this requirement. For example, a 12 unit, 6 unit combination is not acceptable. A 6 unit, 3 unit, 9 unit combination is acceptable.

Free Elective Courses

A free elective is any graded Carnegie Mellon course. However, a maximum of nine units in the form of pass/fail or non-factorable courses (including physical education, StuCo and military science) may be taken as free electives in most CIT degree programs.

Program in General Education for CIT students for the Class of 2016 and later

The environment in which today's engineering graduates will find themselves working is evolving rapidly. Technical innovation is becoming ever more critical to retaining a competitive edge. This is true for individuals, for firms and for nations. Start-ups, as well as established companies, have significant international opportunities but also face more competition in a global economy. Seizing these opportunities and dealing with the associated challenges requires an understanding of the global context in which engineers work, as well as understanding multi-disciplinary approaches to technological innovation across cultures.

The College of Engineering has developed General Education Requirements designed to ensure that our students are ready to work effectively in the global economy, and become the innovators and leaders of tomorrow.

Complete the following requirements to graduate (72 units):

- 76-101 Interpretation and Argument (some students may need to take 76-100 first)
- One course from the following list:

73-100	Principles of Economics	9
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73-230	Intermediate Microeconomics	9
84-104	Decision Processes in American Political Institutions	9
85-102	Introduction to Psychology	9
79-104	Global Histories	9
or one other PPC or SDM course (defined below)		

AFTER FRESHMAN YEAR

Students must complete each of the categories (descriptions of categories follow below) ***Any courses taken on this list that are below 9 units will require additional coursework to complete the requirement :**

- Innovation & Internationalization (I&I)
 - 9 units from the I&I list of courses (which could be two 4.5 unit courses);
- Peoples, Places, and Cultures (PPC) ¹
 - 9 units from the PPC list; or a 9-12 unit course in a modern language at the 200+ level
- Social Analysis and Decision Making (SDM)
 - 9 units from the SDM list of courses (which could be two 4.5 unit courses)
- Writing and Expression (W&E)
 - 9 units from the W&E list of courses (in addition to 76-101)
- General Education Electives
 - At least 18 units (any combination) from the four categories: I&I, PPC, SDM or W&E, or non-technical academic courses from the Dietrich College or the College of Fine Arts excluding those listed on the CIT website under General Education Exclusions (http://engineering.cmu.edu/current_students/services/general_education_requirements/general_education_exclusions.html).

¹ Students can receive exemption through an approved study abroad program (these students would then have three General Education Electives to complete instead of two).

Experiential LEARNING (EL)

- 6 EL points by participating in a variety of approved activities in the following timeframe:
 - 2 points sophomore fall semester (39-210)
 - 2 points sophomore spring semester (39-220)
 - 2 points junior fall semester (39-310)

* A list of acceptable courses to complete these requirements is available at the CIT website, under General Education Requirements (http://engineering.cmu.edu/current_students/services/general_education_requirements).

General Education Categories

People, Places and Cultures (PPC)

PPC courses are designed to help you gain better understanding of the diversity of the world in which we live, and the way in which social, political, economic and technical factors interact to shape that world.

Social Analysis and Decision Making (SDM)

SDM courses are focused on helping you to gain an understanding of different ways in which individuals and societies approach and make decisions.

Innovation and Internationalization (I&I)

I&I courses are intended to expose to you the opportunities and potential that engineering provides with regard to developing cutting-edge technologies and leveraging the fundamental skills you gain in your education to make these pioneering ideas come to fruition in a global context.

Experiential Learning (EL)

Being curious and constantly looking for inspiration are critical parts of lifelong learning. To be successful as an engineer and as a citizen, your education must not stop when you graduate from Carnegie Mellon. The EL requirement aims to encourage a habit of lifelong learning about innovation

and the growing internationalization in engineering and, indeed of many other aspects of the modern world. The goal of this requirement is to help inspire the habits of being open to new ideas as successful, innovative engineers.

To do that, during both semesters of your sophomore year, and the first semester of your junior year, we require you to choose a few related activities that are not part of your formal course work. Examples could include:

- Attending approved seminars and then submitting a one page write up of your thoughts on what you heard;
- Participating in one of the "country courses" or other weekend courses that the University runs; or
- Holding an official leadership position (eg President, Vice President, Secretary, Treasurer) in an organization from this list (http://engineering.cmu.edu/current_students/services/organizations.html).

Additional Majors and Dual Degrees in CIT

A major is defined as a program that must be completed for the granting of a degree. Additional majors comprise a single degree with majors in two separate areas; for example, the degree of Bachelor of Science in Chemical Engineering and an additional major in English. Although the additional major requires the completion of two designated programs, they may have overlapping requirements that can be met simultaneously. The general principle used to measure eligibility for a Carnegie Institute of Technology additional major is that the major (core) requirements of both departments must be completed. Finally, although the student is formally enrolled as an undergraduate in one of the departments (the parent department, which is responsible for scheduling and other administrative actions for the student), the student should apply for the additional major through the second department and coordinate requirements with both departments.

The additional major is to be distinguished from a dual degree program, which results in two separate bachelor's degrees; for example, Bachelor of Science in Chemical Engineering and a Bachelor of Arts in English. The dual degree, though, requires a minimum of 90 units of work in addition to the units required for the first degree. The second degree may be earned in Bachelor of Science or Bachelor of Arts degree programs.

Requirements for students wishing to complete Additional Majors in CIT

Note: This applies to all students.

The student must satisfactorily pass all requirements of the regular and complete program (with the permissible exceptions) leading to a degree in CIT. The minimum number of units required for the additional major is the number required by the parent department or major.

The student takes and satisfactorily completes the courses specified by a second department, usually using elective space available in the first program.

The second department, on the basis of the specified number of courses plus the courses comprising the parent department's regular degree requirements, then certifies that the student has completed the requirements for a major in the second department.

Equivalent technical electives may be substituted at the discretion of the departments/colleges.

Non-technical courses in the curricula can be used to meet the requirements of the second major. But if the second major is not an H&SS department, the program must include a minimum of 72 units of General Education courses to meet CIT requirements for graduation.

Designated Minors Offered by CIT

(for engineering students)

In addition to their regular majors for B. S. degrees, undergraduate students in the Carnegie Institute of Technology can elect to complete an interdisciplinary Designated Minor. These minors have been added to the Carnegie Institute of Technology curriculum to promote flexibility and diversity among the college's engineering students. Independent of major, a student is free, but not required, to pursue a selected designated minor from the following list:

- Audio Engineering
- Automation and Control
- Biomedical Engineering*

- Colloids, Polymers and Surfaces
- Electronic Materials
- Environmental Engineering and Sustainability
- Global Engineering
- Manufacturing Engineering
- Material Science and Engineering
- Mechanical Behavior of Materials
- Robotics*

* Also available for non-CIT students

Complete descriptions of the designated minors can be found at Undergraduate Designated Minors in CIT (p. 119).

To declare a CIT Designated Minor, please contact the director listed for each minor.

Minors for Non-Engineering Students

Students in a non-engineering discipline can also declare certain CIT minors:

- Biomedical Engineering
- Engineering Studies
- Technology and Policy
- Robotics

A full listing of curriculum for these minors when taken by non-engineering students can be found at CIT Minors for Non-Engineering Students (p. 125).

Academic Standards

Grading Practices

For undergraduate grading regulations, please see Undergraduate Academic Regulations (p. 47).

CIT Dean's Honor List

Each semester, Carnegie Institute of Technology recognizes students who have earned outstanding academic records by naming them on the dean's honor list. The criterion for such recognition is a semester quality point average of at least 3.75 while completing at least 36 factorable units and earning no incomplete grades.

Transfer into CIT Departments

Undergraduate students admitted to colleges other than CIT who wish to transfer into a CIT department during their first year should consult with an advisor in the Office of Undergraduate Studies in the CIT Dean's Office. Students admitted to CIT but excluded from certain departments must also consult with the CIT Dean's Office if they wish to transfer into a restricted CIT department.

First-year students can apply for transfer after mid-semester grades for the spring semester have been posted. At that time, a decision will be based on availability of space and the student's academic performance.

CIT undergraduate students beyond the first year wishing to transfer into another CIT department may apply if they are in good academic standing and if there is room in the department of their choice. If the demand for any department exceeds the space available, then the department will admit students based on a comparative evaluation of all applicants at the end of each semester, up to the limit of available space.

Undergraduate students not in CIT who wish to transfer into a CIT department beyond the first year will be considered for transfer on a rolling space available/academic performance basis.

Criteria for all applicants include space in the department, good academic standing, and successful completion of or being currently enrolled in at least one introductory to engineering course (minimally the one of the target major), the appropriate science corequisite, math (21-120, 21-122) and Physics 1 (33-106, 33-111, or 33-131).

Procedure for transfer of students from another university into CIT departments: A student first applies through the Office of Admission. If the Office of Admission believes the applicant is acceptable, the student's record is sent to the appropriate department for evaluation and a decision on acceptance. The CIT department head has the right to refuse to accept the student if there are space restrictions and/or if the student's chance for success in the CIT department is determined to be questionable based on past academic performance.

Academic Actions

In the first year, a student's quality point average below 1.75 in either semester invokes an academic action. For all subsequent semesters, a student's semester QPA or the cumulative QPA (excluding the first year) below 2.0 invokes an academic action.

Probation

The action of probation occurs in the following cases:

- One semester QPA of the first year falls below 1.75.
- The semester QPA of a student in good standing beyond the first year falls below 2.00.

The term of probation is one semester as a full-time student. First year students are no longer on probation at the end of the semester if their semester QPA AND their cumulative QPA are 1.75 or above. Students in the third or subsequent semester of study are no longer on probation at the end of one semester if the semester QPA AND cumulative QPA (excluding the first year) are 2.00 or above.

Probation Continued

A student who is currently on one semester of probation but whose record indicates that the standards are likely to be met by the end of the next semester may be continued on probation at the discretion of the associate dean.

Suspension

A student who does not meet minimum standards at the end of one semester of probation will be suspended.

A first year student will be suspended if the QPA from each semester is below 1.75.

A student in the third or subsequent semester of study will be suspended if the semester QPA or the cumulative QPA (excluding the first year) is below 2.00 for two consecutive semesters.

The normal period of suspension is one academic year (two semesters). At the end of that period a student may petition to return to school (on probation) by completing the following steps:

1. Writing a formal petition requesting to return and receiving permission in writing from the assistant dean for undergraduate studies.
2. Completing a Return from Leave of Absence form from Enrollment Services; and
3. Providing transcripts and clearance forms if the student has been in a degree program at another college or university even though academic credit earned will not transfer back to Carnegie Mellon unless prior approval from the Assistant Dean is given.

Students who are suspended, take a leave of absence or withdraw are required to vacate the campus (including residence halls and Greek houses) within a maximum of two days after the action and to remain off the campus for the duration of the time specified. This action includes debarment from part-time or summer courses at the university for the duration of the period of the action.

Drop

This is a permanent severance. A student is dropped when it seems clear that the student will never be able to meet minimum standards. A student who has been suspended and fails to meet minimum standards after returning to school is dropped.

If students are dropped, they are required to vacate campus (including dormitories and fraternity houses) within a maximum of two days after the action. This action includes debarment from part-time or summer courses.

The relation indicated above between probation, suspension, and drop is normal, not binding. In unusual circumstances, College Council may suspend or drop a student without prior probation.

Graduation Requirements

To be eligible to graduate, undergraduate students must complete all course requirements for their department with a cumulative Quality Point Average of at least 2.0 for all courses taken. For undergraduate students who enrolled at Carnegie Mellon as freshman and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. Some departments may have additional QPA

requirements in order to graduate. Students are encouraged to confirm all graduation requirements with their academic advisor.

Students must be recommended for a degree by the faculty of CIT.

A candidate must meet the residence requirement of having completed at least 180 units at Carnegie Mellon University.

Students must meet all financial obligations to the university before being awarded a degree.

Modification of Graduation Requirements: A student may seek permission to modify graduation requirements by petition to the CIT College Council.

Other Regulations Affecting Student Status

Schedule Changes

Add/drop procedure information and grading procedures for dropped courses can be found under Undergraduate Academic Regulations (p. 47).

Course Add Deadline

The last date to ADD courses is stipulated for each semester on the university calendar - about two weeks after the beginning of a term. This applies to all courses with the following exception: the final date to add half-semester mini-courses is the last class day of the first week of the course.

Course Drop/Withdraw Deadline

CIT undergraduate students may **drop** a course on-line on or before the deadline published in the official university calendar. This deadline is two weeks after mid-semester grades are due in The HUB. The deadline to drop a half-semester mini course is the last day of the fourth week of the mini course. When a course is dropped by the deadlines, the course is removed entirely and disappears from a student's academic record. After the official university deadline to drop, undergraduate students may **withdraw** from a course on-line on or before the last day of classes, excluding final examinations. The deadline to withdraw from a half-semester mini course is the last class day of the mini course. When a student withdraws from a course between the official university deadline to drop a course and the last day of classes, a "W" (Withdrawal) is assigned as a grade, which appears on the student's academic record. This "W" grade does not affect a student's QPA.

CIT undergraduates who are registered as full time students as of the tenth class day are expected to remain full time for the duration of a semester. Full time is defined by being registered for a minimum of 36 factorable units. Students may not drop or withdraw from courses that will reduce their factorable units below 36 unless there are extenuating circumstances for which they obtain approval from the CIT College Council. Undergraduates who are registered as part time (those carrying fewer than 36 factorable units) as of the 10th class day are also subject to the above deadlines to drop or withdraw from a course.

Exceptions to the regulations above will be granted only upon approval of a petition to the College Council.

Undergraduate Designated Minors in the College of Engineering

Undergraduate students in the Carnegie Institute of Technology can elect to complete an interdisciplinary Designated Minor in addition to their regular majors for B.S. degrees. Designated minors have been added to the curriculum of the Carnegie Institute of Technology to promote flexibility and diversity among the college's engineering students. Independent of a student's major, he or she is able to pursue a selected designated minor from the following list:

- Audio Engineering
- Automation and Controls
- Biomedical Engineering
- Colloids, Polymers and Surfaces Technology
- Electronic Materials
- Environmental Engineering
- Global Engineering
- Materials Science and Engineering
- Mechanical Behavior of Materials
- Robotics (see "CIT Minors for Non-Engineering Students (p. 125)")

An engineering student may elect to complete a CIT designated minor. Generally, the student takes all the required courses in an engineering major but uses electives to take courses needed to fulfill the requirements of the designated minor. Upon completion of the requirements of a CIT designated minor and the engineering degree, the minor is a formally recognized on the student's transcript.

Each of the CIT designated minors is administered by a Program Committee consisting of faculty from all major engineering departments who serve as faculty advisors. Each Program Committee certifies the completion of requirements of the designated minor. But the student's major department is responsible for approving the degree with a designated minor after reviewing a student's entire academic record. Any substitution or departure from the published curriculum should be avoided. For example, non-technical courses may not be substituted for required technical courses or electives. Equivalent technical electives offered by a designated minor as substitutions for required courses in a major must be approved by the Head of the student's major department.

Although a student generally can complete a designated minor without increasing the number of required units for graduation, early planning in electing a designated minor is important. A student also may find that some minors are more compatible than others with his/her major because of different relations between various major and minor requirements. The requirements for these CIT designated minors are listed below.

Audio Engineering Designated Minor

Tom Sullivan, Director and Faculty Advisor

This sequence is for candidates who are engineering majors with interest in and/or have background in music, recording, sound-editing and/or other music technology areas; or majors from any discipline in the university who have the above interests and who can meet the prerequisite requirements for the engineering courses in the minor.

Note: Students who do not have the requisite engineering/science/math background should investigate the Minor in Music Technology offered by the School of Music.

Course Requirements

The student must have taken the appropriate prerequisite courses for the listed courses.

Prerequisite Courses, 0-3 units

Beginning Piano is required of students who do not pass a piano proficiency test.

57-103	Elective Studio (Beginning Piano Class)	3
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Music Courses, 40-43 units

Basic Harmony I is required of students who do not qualify for entrance into Harmony I, based on their scores on the theory placement test.

57-101	Introduction to Music Technology	6
57-149	Basic Harmony I	9
or 57-152	Harmony I	
57-173	Survey of Western Music History *	9
57-188	Repertoire and Listening for Musicians	1
57-337	Sound Recording	6

* co-requisite 57-188.

(choose two of the courses below)

15-322	Introduction to Computer Music	9
57-338	Sound Editing and Mastering	6
57-347	Electronic and Computer Music	6
57-438	Multitrack Recording	9

Technical Courses, 33 units

Other courses may be taken with the approval of the Audio Engineering Minor Advisor.

33-114	Physics of Musical Sound	9
18-493	Electroacoustics **	12

** prerequisites 18-220 and 18-290.

(choose one of the courses below)

15-210	Parallel and Sequential Data Structures and Algorithms	12
or 15-214	Principles of Software Construction: Objects, Design, and Concurrency	
18-320	Microelectronic Circuits ⁺	12
18-348	Embedded Systems Engineering **	12
18-349	Embedded Real-Time Systems **	12
18-391	Noisy Signal Representation and Processing *	12

* prerequisite 18-290.

** prerequisite 18-240 and 18-213.

⁺ prerequisite 18-220.

Units required for minor:

73-79

Automation and Controls Designated Minor

Erik Ydstie, Director and Faculty Advisor
Office: DH 4210 A

The objective of the Designated Minor in Automation and Control Engineering is to expose CIT students to the breadth of knowledge required by the modern practice of control and automation. With this objective in mind, the requirements include not only two courses in control system analysis and design, but also courses on real-time computation, software engineering, hardware implementation, and applications. The minor is expected to attract primarily students from Chemical Engineering, Electrical and Computer Engineering, and Mechanical Engineering. The main interdisciplinary component of the minor is between engineering and computer science, although many opportunities exist for creating a program across several CIT departments.

Course Requirements

The minor requires a minimum of six courses as described below:

Note: The course lists below are not necessarily current or complete. Appropriate courses not listed below may be counted toward the requirements for the minor upon approval by one of the departmental the faculty advisors. Students interested in the Automation and Control Engineering Designated Minor are encouraged to look for applicable courses each semester in CIT, CS, and Robotics.

One basic control course:		Units
18-370	Fundamentals of Control	12
24-451	Feedback Control Systems	12
One course on control system analysis and design:		
06-708	Advanced Process Dynamics and Control	12
18-771	Linear Systems	12
One course on computing and software		
15-211	Fundamental Data Structures and Algorithms	12
12-741	Data Management	6
18-549	Embedded Systems Design	12
18-649	Distributed Embedded Systems	12
One course on hardware implementation:		
06-423	Unit Operations Laboratory	9
18-474	Embedded Control Systems	12
18-578	Mechatronic Design	12
One course on applications:		
06-606	Computational Methods for Large Scale Process Design & Analysis	9
16-311	Introduction to Robotics	12
16-761	Mobile Robots	12
24-351	Dynamics	10
xx-xxx	Independent project	12
One elective course:		
xx-xxx	Any course in the list above excluding the basic control course category	6-12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-385	Introduction to Computer Vision	6
15-413	Software Engineering Practicum	12
15-440	Distributed Systems-Time Software	12
18-348	Embedded Systems Engineering	12
18-349	Embedded Real-Time Systems	12
18-491	Fundamentals of Signal Processing	12
18-771	Linear Systems	12
24-341	Manufacturing Sciences	9

Biomedical Engineering Minor

Conrad M. Zapanta, Ph.D.
www.bme.cmu.edu
Campus Office for Student Affairs: Doherty Hall 2100

The minor program is designed for engineering students who desire exposure to biomedical engineering but may not have the time to pursue the Biomedical Engineering additional major. The program is open to students of all colleges and is popular among science majors. In conjunction with other relevant courses, the program may provide a sufficient background for jobs or graduate studies in biomedical engineering. Students interested in a medical career may also find this program helpful.

The Biomedical Engineering minor curriculum is comprised of three core courses and two or three electives. Students pursuing the minor may contact BME Associate Head (<http://www.bme.cmu.edu/people/staff.html#ADH>) for advice. Students interested in declaring Biomedical Engineering minor should contact either the Associate Department Head (<http://www.bme.cmu.edu/people/staff.html#ADH>) of Biomedical Engineering or the Biomedical Engineering Undergraduate Program Coordinator (<http://www.bme.cmu.edu/people/staff.html#UPC>).

Requirements

College of Engineering Students (5 courses):

03-121	Modern Biology	9
42-101	Introduction to Biomedical Engineering (co-req. or pre-req. 03-121)	12
42-202	Physiology (pre-req. 03-121 or permission of instructor)	9
xx-xxx	Elective I (>= 9 units) #	
xx-xxx	Elective II (>= 9 units) +	

Non-Engineering Students (6 courses)

03-121	Modern Biology	9
42-101	Introduction to Biomedical Engineering (co-req. or pre-req. 03-121)	12
42-202	Physiology (pre-req. 03-121 or permission of instructor)	9
xx-xxx	Elective I (>= 9 units) #	
xx-xxx	Elective II (>= 9 units) +	
xx-xxx	A second Introductory Engineering Course* or Any 42-xxx Course Numbered 42-3xx or Higher and worth at Least 9 Units	

Some Special Topics, newly offered or intermittently offered 42-xxx may be acceptable as electives. Students should consult with their advisors and petition the Biomedical Engineering Undergraduate Affairs Committee for permission to include such courses.

Notes

Elective I cannot be a required course in the student's major. It may be

- Any track gateway, restricted elective, or track elective course selected from any of the four Biomedical Engineering tracks. See the online catalog (<http://www.bme.cmu.edu/ugprog/catalog.html>) for a listing of courses.
- Any 42-xxx course with a 42-300 or higher number and worth at least 9 units.
- 42-203 Biomedical Engineering Laboratory (or the cross-listed version 03-206 for students in the Health Professions Program). The course has a limited capacity and priority is given to students who have declared the Additional Major in Biomedical Engineering.**
- One semester of 42-200 Sophomore BME Research Project, 42-300 Junior BME Research Project, 42-400 Senior BME Research Project or 39-500 CIT Honors Research Project. The project must be supervised by a core or courtesy Biomedical Engineering faculty member and for 9 or more units.

+ Elective II must be a Biomedical Engineering track gateway, track elective, or restricted Elective course that is offered by one of the Engineering Departments (06-xxx, 12-xxx, 18-xxx, 19-xxx, 24-xxx, 27-xxx or 42-xxx). The only exception is that 03-232, the biotechnology-focused version of Biochemistry taught each Spring by the Department of Biological Sciences, is also acceptable. Organic Chemistry I 09-217 is a pre-requisite of 03-232.

* Selected from 06-100 Introduction to Chemical Engineering, 12-100 Introduction to Civil and Environmental Engineering, 18-100 Introduction to Electrical and Computer Engineering, 19-101 Introduction to Engineering and Public Policy, 27-100 Engineering the Materials of the Future, or 24-101 Fundamentals of Mechanical Engineering. Note that these courses may involve co-requisites.

** Priority for enrollment in 42-203 or 03-206 will be given to students who have declared the Additional Major in Biomedical Engineering. If sufficient room in the course remains after all majors have been accommodated in a given semester, students who have declared the Biomedical Engineering Designated Minor will be given the next priority for enrollment. If space still allows, other students will be enrolled.

Colloids, Polymers and Surfaces Designated Minor

Annette Jacobson, Director
Office: Doherty Hall 3102B
Website: http://www.cit.cmu.edu/current_students/services/majors_minors/engineering_minors/cps.html

The sequence of courses in the Colloids, Polymers and Surfaces (CPS) designated minor provides an opportunity to explore the science and engineering of fine particles and macromolecules as they relate to complex fluids and interfacially engineered materials. These topics are very relevant to technology and product development in industries that manufacture pharmaceuticals, coatings and paints, pulp and paper, biomaterials, surfactants and cleaning products, cosmetics and personal care products, food, textiles and fibers, nanoparticles, polymer/plastics, composite materials.

Course Requirements

This minor requires a total of five classes. The following four courses are mandatory:

06-609/09-509	Physical Chemistry of Macromolecules	9
06-607	Physical Chemistry of Colloids and Surfaces	9
06-426	Experimental Colloid Surface Science	9
06-466	Experimental Polymer Science	9

In addition, the student must take one course from the following list:

06-221	Thermodynamics	9
24-221	Thermodynamics I	10
27-215	Thermodynamics of Materials	12
33-341	Thermal Physics I	10
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9

Electronic Materials Designated Minor

David W. Greve, Director
Office: Hamerschlag Hall B204

Lisa A. Porter, Co-Director
Office: Roberts Engineering Hall 145

Website: http://www.cit.cmu.edu/current_students/services/majors_minors/engineering_minors/electronic_materials.html

Many of the technological changes in recent decades—notably the rise of digital data processing—has been made possible by continuing advances in the performance of electronic devices. These advances include continuous improvement in microprocessor performance, optical communication bandwidth, and magnetic disk storage capacity. Other new areas of innovation include the development of micromechanical systems and the development of flat panel display technology. These advances depend on interactions between engineers from many different disciplines. In particular, there is a strong interaction between device design and materials engineering and processing.

The Electronic Materials Minor is intended to provide students with a firm basis for the application of electronic materials in advanced systems. This minor is well suited for students who intend to pursue careers in the electronics industry (included, but not limited to, semiconductor integrated circuit design and manufacturing, and magnetic storage engineering). The minor also provides an excellent preparation for students interested in pursuing graduate work in MSE, ECE, or Applied Physics.

This minor is primarily intended to offer ECE and MSE students an understanding of the important features that must be built into a material during processing so that it will function as required in an electronic or

magnetic device. Other students interested in pursuing this minor should consult their advisors to determine whether it will be practical in their own curriculum. Such students are expected to take both 18-100 and 27-201 as introductory courses.

Students in the Electronic Materials program are urged to consider registering for an undergraduate project in addition to the requirements below, especially if they intend to apply to graduate school. The co-directors will make every effort to arrange a suitable project for interested students.

Course Requirements

The minor requires an introductory course together with a minimum of 48 additional units as specified below.

Required Introductory Courses:

18-100	Introduction to Electrical and Computer Engineering (MSE students)	12
27-201	Structure of Materials (ECE students)	9

Elective Courses:

48 additional units, with 24 units from Group A and 24 units from Group B. Some courses are a required part of one of the curricula and consequently cannot be counted again for the minor program.

We have determined that “courses which are a required part of a curriculum” are those which are specifically named in the curriculum requirements. Consequently technical electives and breadth and depth electives may be double-counted.

Group A

27-202	Defects in Materials (ECE students only)	9
06-619	Semiconductor Processing Technology	9
27-542	Processing and Properties of Thin Films	9
27-217	Phase Relations and Diagrams (ECE students only)	12
27-533	Principles of Growth and Processing of Semiconductors	6
27-432	Electronic and Thermal Properties of Metals, Semiconductors and Related Devices	9
27-433	Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices (only if not required in your curriculum)	9
27-551	Properties of Ceramics and Glasses	9
27-216	Transport in Materials (ECE students only)	9
33-225	Quantum Physics and Structure of Matter (ECE students only)	9

Group B

18-310	Fundamentals of Semiconductor Devices	12
18-715	Physics of Applied Magnetism	12
18-716	Advanced Applied Magnetism	12
18-8xx	— An appropriate 800-level course (for example, 18-813, 18-815, 18-819).	

Note: Other appropriate courses may be substituted with the approval of the coordinators in the event that limited course offerings make it impossible to satisfy the requirements as described above.

Environmental Engineering and Sustainability Designated Minor

Neil M. Donahue, Director
Office: Doherty Hall 2116

Concern for the environment now influences a wide range of public, private and engineering decisions. Environmental Engineering is widely recognized as a discipline at the graduate and professional level, and undergraduate training in environmental issues and processes can provide the preparation necessary to pursue this career path, or serve as a useful complement to a career in any of the traditional areas of engineering. Sustainability issues are not considered critical across engineering disciplines. Effective preparation requires broad knowledge and skills in the areas of environmental engineering, sustainability, and environmental policy.

Faculty Advisors

The Environmental Engineering and Sustainability program is a focus for faculty members from diverse engineering backgrounds. The faculty are actively engaged in teaching and conducting research in this field. Current faculty advisors are:

- Biomedical Engineering — Robert Tilton
- Chemical Engineering - Neil Donahue
- Civil and Environmental Engineering — Peter Adams and Scott Matthews
- Electrical and Computer Engineering — Marija Ilic
- Engineering and Public Policy — Edward Rubin
- Mechanical Engineering — Ryan Sullivan
- Materials Science and Engineering — Robert Heard

To declare this minor, submit a minor declaration form to the Department of Civil and Environmental Engineering.

Course Requirements

The requirements include two core courses, three technical electives, and two policy electives.

A1. Core Courses in Sustainability 12 units

Select one course from:

12-712/19-717	Introduction to Sustainable Engineering	12
12/19-714	Environmental Life Cycle Assessment	12

A2. Core Courses in Environmental Engineering 9 units

Select one course from:

12-351	Environmental Engineering	9
24/19-424	Energy and the Environment	9
12-651	Air Quality Engineering	9
24-425	Combustion and Air Pollution Control	9
12-702	Fundamentals of Water Quality Engineering	12

B. Technical Electives in Environmental Engineering and Sustainability 27 units

Select three from the following list:

03-121	Modern Biology	9
09-106	Modern Chemistry II	10
09-510	Chemistry and Sustainability	9
12-201	Geology	9
12-351	Environmental Engineering	9
12-651	Air Quality Engineering	9
12-657	Water Resource Systems Engineering	9
12-658	Hydraulic Structures	9
12-702	Fundamentals of Water Quality Engineering	12
12-712/19-717	Introduction to Sustainable Engineering	12
12/19-714	Environmental Life Cycle Assessment	12
12-718	Environmental Engineering, Sustainability, and Science Project	12
24/19-424	Energy and the Environment	9

24-425	Combustion and Air Pollution Control	9
27-323	Powder Processing of Materials	9
27-367	Selection and Performance of Materials *	6
27-421	Processing Design *	6
48-315	Environment I: Climate & Energy	9
79-289	Animal Planet: An Environmental History of People and Animals	6

* 6 units; must be combined with 3 additional units

C. Policy Electives 18 units

Select two from the following list of humanities/social science-oriented courses:

06/19-365	Water Technology Innovation and Policy	9
19-448	Science, Technology & Ethics	9
48-576	Mapping Urbanism	9
73-148	Environmental Economics	9
73-358	Economics of the Environment and Natural Resources	9
73-359	Benefit-Cost Analysis	9
76-319	Environmental Rhetoric	9
79-303	Pittsburgh and the Transformation of Modern Urban America	6
79-372	Perspectives on the Urban Environment	9
80-244	Environmental Ethics	9
88-220	Policy Analysis I	9
88-221	Policy Analysis II	9
88-223	Decision Analysis and Decision Support Systems	9
90-758	Ethics & Public Policy in a Global Society	6
90-765	Cities, Technology and the Environment	6
90-789	Sustainable Community Development	12
90-798	Environmental Policy & Planning	12

NOTES:

1. Courses cannot be double-counted for lists A and B.
2. Courses used to fulfill the first year restricted technical electives for CIT **cannot** be double counted for list B requirements
3. A group of three environmental policy courses, from List C, excluding Heinz courses, may be counted as fulfilling the general education depth requirement required of all CIT students if and only if the student completes the Environmental Engineering and Sustainability Minor. Approval of the selected courses from List C for fulfillment of this CIT depth sequence is required from the student's home department advisor.
4. Courses required within a student's CIT major **can** be double counted for list A or B course requirements, with the exception that 12-351 Environmental Engineering can be counted toward completion of the minor for non-CEE students only.
5. Students may take up to two list B courses in their home department. One list B course must be from outside their home department. EPP double majors should NOT consider EPP their home department. BME double majors should NOT consider BME their home department.
6. At most ONE 48-xxx course can be used as a List B course and one as a List C course. The 48-xxx courses may not be acceptable as technical electives by some CIT engineering departments.
7. Other environmentally related technical electives with similar or related content may be substituted for List B courses **only** with written permission of the Director.
8. Other humanities and social science courses with similar or related content may be substituted for Type C courses **only** with written permission of the Director.
9. A list of available courses for the minor in each semester is provided to students who have declared the minor and to all faculty advisors for the minor.

Global Engineering Designated Minor

Treci Bonime, Director
Office: Scaife Hall 110

Many engineers work on international projects or for multinational companies. Carnegie Mellon is an international community, with a significant fraction of international students and many events featuring foreign speakers and cultural experiences. This minor is intended for engineering students interested in broadening their background in international experiences and global awareness and engagement.

Course Requirements

International Management (1 course)

Complete one course in international management or business such as:

70-342	Managing Across Cultures	9
70-365	International Trade and International Law	9
70-381	Marketing I	9
70-430	International Management	9
88-384	Conflict and Conflict Resolution in International Relations	9

Or approved equivalent.

Regional Specialization (1 course)

Complete one course in non-US History, international politics, or literature in a single region of the world. See the list at http://www.cit.cmu.edu/global/courses_degrees.html below for examples (Note: Please consult with the Global Engineering director before planning your course schedule, as some course information may have changed).

Ethics (1 course)

Any ethics course that provides some exposure to international ethics issues such as:

70-332	Business, Society and Ethics	9
80-136	Social Structure, Public Policy & Ethics	9
80-244	Environmental Ethics	9
80-247	Ethics and Global Economics	9

Or approved equivalent

Modern Languages

Demonstration of basic competency in a foreign language via one of the three options listed below:

- Complete one (1) Modern Languages course at the 200 level, with a minimum grade of C, or
- Achieve a score of 4 or higher in one foreign language Advanced Placement examination, or
- Demonstrate equivalent proficiency to the satisfaction of the Department of Modern Languages

Study/Work Abroad

Study or engineering internship work abroad for a semester or a summer. The region visited should be consistent with the language and regional culture/history studied.

Materials Science and Engineering Designated Minor

Michael E. McHenry, Director
Office: Roberts Engineering Hall 243

The Designated Minor in Materials Science and Engineering provides the CIT student with a background in the field of Materials Science and Engineering.

This minor is open to all CIT students, with the exception of MSE majors. All required and elective courses are taught within the MSE Department.

Course Requirements

The minor requires a minimum of 45 units, with two semester long required courses (the first being a sequence of two minis).

Prerequisites

Students wishing to take the MSE minor must have prerequisite thermodynamics and transport courses. The prerequisite MSE courses may be substituted for by a thermodynamics and transport course in another engineering discipline.

Core Courses (21 units)

27-211	Structure of Materials (Minor Option)	6
27-212	Defects in Materials (Minor Option)	6
27-217	Phase Relations and Diagrams	12

The laboratories with these courses are not required as core but will be counted as elective units if desired.

Elective Courses (24 units minimum)

The student must select a minimum of 24 units from the following list:

27-100	Engineering the Materials of the Future	12
27-301	Microstructure and Properties I	9
27-311	Polymeric Biomaterials	9
27-323	Powder Processing of Materials	9
27-324	Introduction to Polymer Science and Engineering	9
27-325	Polymer Physics and Morphology	9
27-357	Introduction to Materials Selection	6
27-367	Selection and Performance of Materials	6
27-582	Phase Transformations in Solids	9
27-433	Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices	9
27-432	Electronic and Thermal Properties of Metals, Semiconductors and Related Devices	9
27-421	Processing Design	6
27-445	Structure, Properties and Performance Relationships in Magnetic Materials	9
27-591	Mechanical Behavior of Materials	9
27-454	Supervised Reading	Var.
27-533	Principles of Growth and Processing of Semiconductors	6
27-555	Materials Project I	Var.
27-565	Nanostructured Materials	9
27-542	Processing and Properties of Thin Films	9
27-551	Properties of Ceramics and Glasses	9
27-566	Special Topics in MSE:Using Matls Informatics to Assess Societal Impact of Matls	9
27-592	Solidification Processing	9
42-444	Medical Devices	9

Mechanical Behavior of Materials Designated Minor

Warren M. Garrison, Jr., Director
Office: Wean Hall 3303

An understanding of mechanical behavior is important to both the development of new materials and the selection of appropriate materials for many applications. The mechanical behavior of materials is best investigated and understood by integrating solid mechanics with the microstructural basis of flow and fracture. The purpose of this minor is to allow a formal basis for students to pursue an integrated approach to the mechanical behavior of materials.

Although this minor is open to all CIT students, only students in the departments of Civil Engineering, Materials Science and Engineering, and Mechanical Engineering can take advantage of the double counting permitted for some courses in their department majors. Students in other departments may have difficulty in fulfilling the requirements in four years.

Faculty Advisors

- Chemical Engineering — Paul Sides
- Electrical and Computer Engineering — David W. Greve
- Mechanical Engineering — Paul S. Steif
- Materials Science and Engineering — Warren M. Garrison, Jr.

Course Requirements

The minor requires six courses: three core courses, two solid mechanics courses, and one materials science course. In satisfying these course requirements, each student must take three out-of-department courses. Each student is required to complete three core courses:

Core Courses:

27-201	Structure of Materials	9
27-591	Mechanical Behavior of Materials	9-12
or 27-791	Mechanical Behavior of Materials	
12-212	Statics	9
or 24-261	Statics	

Group A: Materials Science Courses

Each student must take one course from this list of Materials Science courses:

27-202	Defects in Materials ¹	9
27-357	Introduction to Materials Selection ²	6
27-551	Properties of Ceramics and Glasses	9
42-411	Engineering Biomaterials	9

¹ 27-202 cannot be used by MSE students to satisfy the requirements of the minor.

² 27-357 cannot be used by MSE students to satisfy the requirements of the minor.

Group B: Solid Mechanics Courses

Each student must take two of the following Solid Mechanics courses:

12-231	Solid Mechanics	9
or 24-262	Stress Analysis	
12-635	Structural Analysis	9
or 24-351	Dynamics	

Students should check with the director of the program or their faculty advisor for an up-to-date list of relevant courses that will count towards this minor. For more information, please consult the Undergraduate Course Catalog and the current Schedule of Classes.

Engineering Minors for Non-Engineering Students

Biomedical Engineering Minor

(for non-engineering students)

Conrad M. Zapanta, Ph.D.
www.bme.cmu.edu

Campus Office for Student Affairs: Doherty Hall 2100

BME offers a minor program for those non-CIT students who desire coordinated training in BME. The Biomedical Engineering Minor is designed to train students to apply engineering techniques to problems in medicine and biology. Emphasis is placed on describing biological organisms as engineering systems and on applying engineering technology to clinical and laboratory situations.

Upon completing the Biomedical Engineering Minor, the student may elect to continue graduate studies in Biomedical engineering or basic biomedical sciences at either the master's or Ph.D. level. In addition, some of the courses in BME minor will assist students in preparing for medical school. Students who pursue jobs in biomedical engineering are involved in developing and improving medical devices, automating medical procedures using information technology, characterizing the operation of physiological systems, designing artificial organs, and altering microbes and mammalian cells for the production of useful drugs and chemicals.

Students in the minor program can choose from a wide range of electives to build skills in a number of areas of biomedical engineering. Students who wish to complete the Biomedical Engineering Designated Minor should complete the CIT Minor Request Form (http://www.cit.cmu.edu/files/documents/minor_request.pdf) and return it to the Associate Head of the Department of Biomedical Engineering (<http://www.bme.cmu.edu/contact.html>).

Requirements for non-CIT students: six courses, minimum of 60 units

03-121	Modern Biology	9
42-101	Introduction to Biomedical Engineering	12
42-202	Physiology (pre-req. 03-121 or permission of instructor)	9
xx-xxx	Elective I #	
xx-xxx	Elective II +	
xx-xxx	A second Introductory Engineering Course* or Any 42-xxx Course Numbered 42-3xx or Higher and Worth at Least 9 Units	

Some Special Topics, newly offered or intermittently offered 42-xxx may be acceptable as electives. Students should consult with their advisors and petition the Biomedical Engineering Undergraduate Affairs Committee for permission to include such courses as track electives.

Notes:

- # This course cannot be a required course in the student's major. It may be
1. Any Track Gateway, Track Elective, Restricted Elective, or Track Capstone course selected from any of the four Biomedical Engineering tracks. A list of track courses is provided under the BME Additional Major listing in the catalog and is periodically updated on the website.
 2. Any 42-xxx course with a 42-300 or higher number and worth at least 9 units.
 3. 42-203 Biomedical Engineering Laboratory (or the cross-listed version 03-206 for students in the Health Professions Program)**.
 4. One semester of 42-200 Sophomore BME Research Project, 42-300 Junior BME Research Project, 42-400 Senior BME Research Project or 39-500 Honors Research Project, as long as the research project is supervised by a regular or courtesy Biomedical Engineering faculty member and the project is conducted for 9 or more units of academic credit.

+ Elective II must be a Biomedical Engineering Track Gateway, Track Elective, Restricted Elective, or Track Capstone course that is offered by one of the CIT Departments (06-xxx, 12-xxx, 18-xxx, 19-xxx, 24-xxx, 27-xxx or 42-xxx). The only exception is that 03-232, the biotechnology-focused version of Biochemistry taught each Spring by the Department of Biological Sciences, is also acceptable, provided students meet the prerequisites and corequisites for that course.

* Select either 06-100 Introduction to Chemical Engineering, 12-100 Introduction to Civil and Environmental Engineering, 18-100 Introduction to Electrical and Computer Engineering, 19-101 Introduction to Engineering and Public Policy, 27-100 Engineering the Materials of the Future, or 24-101

Fundamentals of Mechanical Engineering. Note that corequisites are required for these courses

** Priority for enrollment in 42-203 or 03-206 will be given to students who have declared the Additional Major in Biomedical Engineering. If sufficient room in the course remains after all majors have been accommodated in a given semester, students who have declared the Biomedical Engineering Designated Minor will be given the next priority for enrollment. If space still allows, other students will be enrolled.

Engineering Studies Minor

(for non-engineering students)

Kurt Larsen, Director

Office: Scaife Hall 110

Carnegie Mellon undergraduate students enrolled in colleges other than engineering can complete a Minor in Engineering Studies in addition to their regular majors. Students pursuing this minor are required to complete courses from at least two different engineering departments in order to assure some breadth of exposure to engineering. In addition, the minor provides students the opportunity to pursue an in-depth concentration in a particular field of engineering.

For the Minor in Engineering Studies, students must complete five engineering courses as follows and must earn a cumulative QPA of 2.00 in these five courses. Students may declare the minor by contacting the Director after they have successfully completed two introductory engineering courses (from list #1 below).

Double counting of core courses in student's primary major is not permitted.

Because of the nature of the courses offered by Engineering and Public Policy, only two EPP courses (including 19-101) can be used toward the minor requirements. Students need special permission to use an Engineering and Public Policy course (EPP-19-xxx) toward minor requirements. Students interested in EPP coursework should consider the Technology and Policy minor instead.

Requirements

1. Two of the following:

12-100	Introduction to Civil and Environmental Engineering	12
18-100	Introduction to Electrical and Computer Engineering	12
19-101	Introduction to Engineering and Public Policy	12
24-101	Fundamentals of Mechanical Engineering	12
27-100	Engineering the Materials of the Future	12
42-101	Introduction to Biomedical Engineering	12
06-100	Introduction to Chemical Engineering	12

2. Three courses of at least 9 units each from one or more CIT departments

3. Up to one of the following Robotics courses can count toward the ES minor. But it cannot be double-counted with the Robotics minor or double major.

16-311	Introduction to Robotics	12
16-362	Mobile Robot Programming Laboratory	12
16-384	Robot Kinematics and Dynamics	12
16-385	Computer Vision	9
16-421	Vision Sensors	12
16-474	Robotics Capstone	12

4. **NOTE:** The following courses may NOT be included as part of the Minor in Engineering Studies. In addition to the courses listed, most EPP courses (19-xxx) are not permissible for the minor and students should contact the Director for prior approval of EPP courses.

06-262	Mathematical Methods of Chemical Engineering	12
12-201	Geology	9
15-213	Introduction to Computer Systems	12

18-200	Emerging Trends in Electrical and Computer Engineering	1
18-202	Mathematical Foundations of Electrical Engineering	12
18-213	Introduction to Computer Systems	12
24-201	Engineering Graphics	9
24-311	Numerical Methods	12
39-200	Business for Engineers	9
42-202	Physiology	9

Technology and Policy Minor

(for non-engineering students)

Deanna H. Matthews, Director Office: Baker Hall 129

The Technology and Policy Minor is administered by the Department of Engineering and Public Policy (EPP) for students who are majoring in areas other than engineering. The Technology and Policy Minor is designed to give students a basic understanding of the interactions between technology, society and policy and some project experience in problems involving technology and policy.

Pre-requisites: Students should have prerequisite knowledge in economics (73-100 Principles of Economics or higher level economics course) and statistics (36-202 Statistical Methods or higher level statistics course) in order to pursue the Technology and Policy Minor.

Course Requirements

19-101	Introduction to Engineering and Public Policy	12
19-301	Decision Making Methods for EPP or other approved Decision Science course	9
or 19-351	Applied Methods for Technology-Policy Analysis	
19-451	EPP Projects	12
or 19-452	EPP Projects	
xx-xxx	Two EPP Technology-Policy Electives	18

EPP Technical Electives include courses in CIT, MCS, or SCS that address problems at the society-technology interface and the means of analyzing these issues. A list of qualifying Technology-Policy electives is assembled each semester and is available from the EPP Department. Example Technology-Policy electives include:

19-211	Ethics and Policy Issues in Computing	9
19-365	Water Technology Innovation and Policy	9
19-402	Telecommunications Technology, Policy & Management	12
19-411	Global Competitiveness: Firms, Nations and Technological Change	9
19-424	Energy and the Environment	9

Students must earn a cumulative QPA of 2.0 in all courses taken for the minor. Required courses taken for a student's primary major may not be counted toward the Technology and Policy Minor. Elective courses for a student's primary major or courses fulfilling general education requirements may be counted, however.

Robotics Minor

Director: Dr. Howie Choset
Administrative Coordinator: Julie Goldstein
Website: http://www.ri.cmu.edu/education/ugrad_minor.html

The Minor in Robotics provides an opportunity for undergraduate students at Carnegie Mellon to learn the principles and practices of robotics through theoretical studies and hands-on experience with robots. The Minor is open to students in any major of any college at Carnegie Mellon. Students initially learn the basics of robotics in an introductory robotics overview course. Additional required courses teach control systems and robotic manipulation. Students also choose from a wide selection of electives in robotics, perception, computer vision, cognition and cognitive science, or computer graphics. Students have a unique opportunity to undertake independent research projects, working under the guidance of Robotics Institute faculty members; this provides an excellent introduction to robotics research for those considering graduate studies.

All Robotics Minors are required to take Introduction to Robotics (16-311). This course is designed to help students understand the big picture of what is going on in robotics through topics such as kinematics, mechanisms, motion planning, sensor based planning, mobile robotics, sensors, and vision. The minor also requires students to take a controls class and a kinematics class. These courses provide students with the necessary

intuition and technical background to move on to more advanced robotics courses. In addition to the required courses, students must take 2 electives. The student must have course selection approved by the Director during the application submission process.

A 2.5 QPA in the Minor curriculum is required for graduation. Courses that are taken Pass/Fail or audited cannot be counted for the Minor.

Admission

Admission to the Undergraduate Minor in Robotics is limited to current Carnegie Mellon students. Students interested in signing up for the minor should fill out the application form (https://www-preview.ri.cmu.edu/education/apply/ugrad_appform.html).

Prerequisite

Successful candidates for the Robotics Minor will have prerequisite knowledge of C language, basic programming skills, and familiarity with basic algorithms. Students can gain this knowledge by taking 15-122 Principles of Imperative Computation.

Required Courses

Overview:		Units
16-311	Introduction to Robotics	12

Controls (choose one of the following):

06-464	Chemical Engineering Process Control	9
24-451	Feedback Control Systems	12
18-370	Fundamentals of Control	12
16-299	Introduction to Feedback Control Systems (Computer Science)	12
16-xxx	Upper-level RI course with instructor and Program Director's permission	

Kinematics (choose one of the following):

16-384	Robot Kinematics and Dynamics	12
24-355	Kinematics and Dynamics of Mechanisms	9
16-xxx	Upper-level RI course with instructor and Program Director's permission	

Electives

Two Electives (chosen from the following):		Units
10-601	Introduction to Machine Learning	12
11-344	Machine Learning in Practice	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-424	Foundations of Cyber-Physical Systems	12
15-462	Computer Graphics	12
15-463	Computational Photography	12
15-491	Special Topic: CMRoboBits: Creating Intelligent Robots	12
15-494	Special Topic: Cognitive Robotics	12
16-264	Humanoids	12
16-362	Mobile Robot Programming Laboratory	12
16-385	Computer Vision	9
16-421	Vision Sensors	12
16-423	Designing Computer Vision Apps	12
16-597	Undergraduate Reading and Research	Var.
18-342	Fundamentals of Embedded Systems	12
18-348	Embedded Systems Engineering	12
18-349	Embedded Real-Time Systems	12
18-549	Embedded Systems Design	12
18-578	Mechatronic Design	12
85-370	Perception	9
85-382	Consciousness and Cognition	9
85-395	Applications of Cognitive Science	9
85-412	Cognitive Modeling	9
85-419	Introduction to Parallel Distributed Processing	9
85-426	Learning in Humans and Machines	9

Graduate level Robotics courses may be used to meet the elective requirement with permission from the Program Director. Graduate level Mechanical Engineering and Electrical and Computer Engineering courses

that are relevant to robotics may be used to meet the elective requirement with permission from the Program Director.

Students may count up to 12 units of 16-597 Undergraduate Reading and Research towards the degree requirements.

Double-Counting Restriction

Courses being used to satisfy the requirements for the Robotics Minor may not be counted towards another minor. Students are permitted to double count a maximum of two courses from their Major (excluding General Education requirements) towards the Minor in Robotics. Free electives are not subject to the double counting policy.

Department of Biomedical Engineering

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Biomedical Engineering Overview

Biomedical engineering education at Carnegie Mellon reflects the belief that a top biomedical engineer must be deeply trained in both a traditional engineering practice and biomedical sciences. The unique additional major program leverages extensive collaborations with sister departments in the College of Engineering and with major medical institutions in Pittsburgh. This collaborative approach, combined with a rigorous engineering education, confers unique depth and breadth to the education of Biomedical Engineering graduates.

Students who elect Biomedical Engineering as a major must also declare a major in one of the traditional engineering disciplines: Chemical Engineering, Civil & Environmental Engineering, Electrical & Computer Engineering, Materials Science & Engineering, or Mechanical Engineering.

The curriculum, demanding but readily feasible to complete in four years, is highly rewarding to motivated students.

Common Requirements for the Additional Major

The Biomedical Engineering additional major program takes advantage of curricular overlaps between Biomedical Engineering and traditional engineering majors, such that the dual major can be completed in four years with only a modest increase in course requirements. The requirements for Biomedical Engineering consist of the core, the tracks, and the capstone design course. The core exposes students to basic facets of biomedical engineering to lay a foundation. The tracks allow students to build depth in a specific aspect of biomedical engineering. The capstone design (<http://www.bme.cmu.edu/ugprog/design.html>) engages students in team work to develop real-world applications.

While most tracks are designed to parallel a traditional engineering discipline, a General Biomedical Engineering track is available for students intending on pursuing graduate studies or medical school, and a self-designed track allows students to pursue specific areas not covered by the pre-defined tracks. **The additional major in Biomedical Engineering should be declared at the same time when declaring a traditional engineering major.**

Course Requirements for the Additional Major Degree

Student majoring in Biomedical Engineering must meet three sets of requirements: 1) Biomedical Engineering (BME), 2) a traditional engineering discipline, and 3) CIT General Education (http://engineering.cmu.edu/current_students/services/general_education_requirements/general_education_2016) sequence. The Quality Point Average (QPA) for courses that count toward the additional major must be 2.00 or better. No course taken on a pass/fail or audit basis may be counted toward the additional major.

The course requirements for the BME portion of the additional major are as follows:

Core Courses (all required)

		Units
42-101	Introduction to Biomedical Engineering- Fall and Spring	12
42-201	Professional Issues in Biomedical Engineering- Fall and Spring	3
42-202	Physiology- Fall and Spring	9
42-203	Biomedical Engineering Laboratory- Fall and Spring [#]	9
03-121	Modern Biology- Fall and Spring	9
42-401	Foundation of BME Design	6
42-402	BME Design Project- Spring	9

[#] Also known as 03-206 for Health Professions Program students.

* 42-401 serves as the precursor/pre-requisite for 42-402 BME Design Project.

Tracks (Completion of one track is required)

- Biomaterials and Tissue Engineering (BMTE (<http://www.bme.cmu.edu/ugprog/bmte.html>))
- Biomechanics (BMEC (<http://www.bme.cmu.edu/ugprog/bmec.html>))
- Biomedical Signal and Image Processing (BSIP (<http://www.bme.cmu.edu/ugprog/bsip.html>))
- Cellular and Molecular Biotechnology (CMBT (<http://www.bme.cmu.edu/ugprog/cmbt.html>))
- General Biomedical Engineering (GBME (<http://www.bme.cmu.edu/ugprog/gbme.html>))
- Self-Designed Biomedical Engineering (SBME (<http://www.bme.cmu.edu/ugprog/sbme.html>))

Biomaterials and Tissue Engineering (BMTE) Track

Overview

The BMTE track addresses issues at the interface of materials science, biology and engineering. The topics include the interactions between materials and cells or tissues, the effects of such interactions on cells and tissues, the design of materials for biological applications, and the engineering of new tissues.

Targets

The BMTE track is ideal for students interested in combining the education of Biomedical Engineering with Materials Science & Engineering or with Chemical Engineering. Both provide the necessary foundation in chemistry and/or materials science. Students of this track may develop careers in biotechnology, tissue engineering, biopharmaceuticals, and medical devices that leverage materials properties.

Requirements

In addition to the Biomedical Engineering core courses, students in the BMTE Track must take the following combination of courses:

- One (1) BMTE Gateway course
- One (1) **Required** BMTE elective
- Two (2) other Electives (either one of the two options)
 1. One (1) BMTE Elective (either **Required** or **Additional**) and one (1) **Restricted** Elective
 2. Two (2) Additional BMTE Electives

BMTE Gateway Course[#]

03-231	Biochemistry I- Fall	9
03-232	Biochemistry I- Spring [#]	9

[#] Note that only 03-232 satisfies Chemistry Engineering course requirements. Either 03-231 or 03-232 satisfies Materials Science & Engineering requirements.

BMTE Electives

Required BMTE Electives (must take one of the following)

42/27-411	Engineering Biomaterials- Fall	9
42-612/27-520	Tissue Engineering- Spring	12

Additional BMTE Electives

03-240	Cell Biology- Spring	9
09-217	Organic Chemistry I- Fall ^{2,#}	9
or 09-218	Organic Chemistry II	
42-620	Engineering Molecular Cell Biology- Fall	12
42-624	Biological Transport and Drug Delivery- Spring	9
42-643/24-615	Microfluids- Intermittent	12
42-698	Special Topics-B Stem Cell Engineering - Fall, every other year	9
42-698	Special Topics-G Molecular and Micros-Scale Polymeric Biomaterials in Medicine - Spring, every other year	9
42-699	Special Topics-N Applied Nanoscience and Nanotechnology in Biomedical Engineering - Fall	12

² Note that either 09-217 or 09-218 (offered in the Spring), but not both, may be counted as a BMTE Elective.

Chemical Engineering requirement

Restrictive Elective Courses (choose at most one)

42-698	Special Topics-A Bioinstrumentation - Fall	9
42-698	Special Topics-C Introduction to Biomedical Signal Processing - Fall	9
42-698	Special Topics-D Engineering in Medicine - Fall	9
42-698	Special Topics-E Surgery for Engineers- Spring	9
42-698	Special Topics-F Technological Innovation in Biomedical Engineering - Fall	9
42-698	Special Topics-H Systems Modeling and Analysis for Biomedical Engineering- Fall	9
42-699	Special Topics-G Computational Methods in Biomedical Engineering - Spring	12
42-x00	BME Research *	Var.
39-500	Honors Research Project *	Var.

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 Honors Research Project) must be on a BME topic supervised or co-supervised by a BME faculty member and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as BMTE track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as BMTE track electives.

Sample schedules can be found on the BMTE (<http://www.bme.cmu.edu/upprog/bmte.html>) page on the BME website.

Biomechanics (BMEC) Track

Overview

The BMEC track addresses the application of solid or fluid mechanics to biological and medical systems. It provides quantitative understanding of the mechanical behavior of molecules, cells, tissues, organs, and whole organisms. The field has seen a wide range of applications from the optimization of tissue regeneration to the design of surgical and rehabilitation devices.

Targets

The BMEC track is ideally suited to the combined education of Biomedical Engineering and Mechanical Engineering or Civil & Environmental Engineering. Both provide the necessary foundation in the underlying physical principles and their non-Biomedical Engineering applications. This track may also appeal to students of Electrical & Computer Engineering who are interested in biomedical robotics. Education in biomechanics enables students to pursue careers in medical devices or rehabilitation engineering.

Requirements

In addition to the Biomedical Engineering core courses, students in the BMEC Track must take the following combination of courses:

- One (1) BMEC Gateway Course

- One (1) **Required** BMEC Elective
- Two (2) other Electives (either one of the two options)

1. One (1) BMEC Elective (either **Required** or **Additional**) and one (1) Restricted Elective
2. Two (2) BMEC Electives (either **Required** or **Additional**)

BMEC Gateway Course¹

24-231 Fluid Mechanics

06-261 Fluid Mechanics

12-355 Fluid Mechanics

12-355 Fluid Mechanics

¹Note that 24-231 Fluid Mechanics satisfies Mechanical Engineering course requirements, 06-261 Fluid Mechanics satisfies Chemical Engineering course requirements, and 12-355 Fluid Mechanics satisfies Civil & Environmental Engineering course requirements.

BMEC Electives

Required BMEC Electives (must take at least one of the following)

42-341	Introduction to Biomechanics- Fall	9
42-645/24-655	Cellular Biomechanics- Intermittent	9
42-646/24-657	Molecular Biomechanics- Spring, every other year	9
42-648	Cardiovascular Mechanics	12
42-698	Special Topics-I Biofluid Mechanics- Fall	9

Additional BMEC Electives

33-441/03-439	Introduction to BioPhysics- Fall	10
42-444	Medical Devices- Fall and Spring	9
42-447	Rehabilitation Engineering- Fall	9
42-640/24-658	Computational Bio-Modeling and Visualization- Spring	12
42-643/24-615	Microfluids-Spring, Intermittent	12
42-647	Introduction to Continuum Biomechanics- Spring	12

Restrictive Elective Courses (choose at most one)

42-698	Special Topics-A Bioinstrumentation - Fall	9
42-698	Special Topics-C Introduction to Biomedical Signal Processing - Fall	9
42-698	Special Topics-D Engineering in Medicine - Fall	9
42-698	Special Topics-E Surgery for Engineers- Spring	9
42-698	Special Topics-F Technological Innovation in Biomedical Engineering - Fall	9
42-698	Special Topics-H Systems Modeling and Analysis for Biomedical Engineering- Fall	9
42-699	Special Topics-G Computational Methods in Biomedical Engineering - Spring	12
42-x00	BME Research *	Var.
39-500	Honors Research Project *	Var.

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 Honors Research Project) must be on a BME topic supervised or co-supervised by a BME faculty member and conducted for 9 or more units of credit.

Some Special Topics, newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives.

Sample schedules can be found on the BMEC (<http://www.bme.cmu.edu/upprog/bmec.html>) page on the BME website.

Biomedical Signal and Image Processing (BSIP) Track

Overview

The BSIP track addresses bio/medical phenomena based on the information embedded in sensor-detected signals, including digital images and nerve electrical pulses. Students in this track will gain understanding of the technologies involved in acquiring signals and images, the mathematical principles underlying the processing and analysis of signals, and the applications of signal/image processing methods in basic research and medicine.

Targets

This track aligns most naturally with a combined education of Biomedical Engineering and Electrical & Computer Engineering, which lays a solid foundation in signal processing principles. This track prepares students for careers in medical imaging or smart prosthetics. It also interfaces with many clinical practices including radiology, neurology/neurosurgery, and pathology.

Requirements

In addition to the Biomedical Engineering core courses, students in the BSIP Track must take the following combination of courses:

- One (1) BSIP Gateway course
 - One (1) **Required** BSIP elective
 - Two (2) other Electives (either one of the two options)
1. One (1) BSIP Electives (either **Required** or **Additional**) and one (1) **Restricted** Elective
 2. Two (2) BSIP Electives (either **Required** or **Additional**)

BSIP Gateway Course

18-290 Signals and Systems - Fall/Spring

BSIP Electives

Required BSIP Electives (must take at least one of the following)

42-431/18-496	Introduction to Biomedical Imaging and Image Analysis- Fall	12
42-630	Introduction to Neuroscience for Engineers- Spring	12
42-631	Neural Data Analysis- Fall	9
42-632	Neural Signal Processing- Spring	12

Additional BSIP Electives

03-534	Biological Imaging and Fluorescence Spectroscopy- Spring	9
15-386	Neural Computation- Spring	9
18-491	Fundamentals of Signal Processing- Fall ¹	12
or 18-792	Advanced Digital Signal Processing	
42-426	Biosensors and BioMEMS- Spring, every other year	9
42-447	Rehabilitation Engineering- Fall	9
42-640/24-658	Computational Bio-Modeling and Visualization- Spring	12
42-698	Special Topics- A : Bioinstrumentation - Fall	9
42-698	Special Topics- P Introduction to Biophotonics- Fall	9
42-735	Medical Image Analysis- Spring	12

¹ Note that either 18-491 or 18-792 (offered in Spring), but not both, may be counted as a BSIP Elective.

Restrictive Elective Courses (choose at most one)

42-698	Special Topics-D Engineering in Medicine - Fall	9
42-698	Special Topics-E Surgery for Engineers- Spring	9
42-698	Special Topics-F Technological Innovation in Biomedical Engineering - Fall	9
42-698	Special Topics-H Systems Modeling and Analysis for Biomedical Engineering- Fall	9
42-699	Special Topics-G Computational Methods in Biomedical Engineering - Spring	12
42-x00	BME Research *	Var.
39-500	Honors Research Project *	Var.

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 Honors Research Project) must be on a BME topic supervised or co-supervised by a BME faculty member and conducted for 9 or more units of credit.

Some Special Topics, newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives.

Sample schedules can be found on the BSIP (<http://www.bme.cmu.edu/ugprog/bsip.html>) page on the BME website.

Cellular and Molecular Biotechnology (CMBT) Track

Overview

The CMBT track emphasizes fundamentals and applications of biochemistry, biophysics, and cell biology, and processes on the nanometer to micrometer size scale. Students in this track acquire understanding of the molecular and cellular bases of life processes, and build skills in quantitative modeling of live cell-based biotechnologies and in technologies that exploit the unique properties of biomolecules in non-biological settings.

Targets

The CMBT track is ideally suited for the combined education of Biomedical Engineering and Chemical Engineering, which provides a strong core of chemistry and molecular processing principles. The track may also interest students of Mechanical Engineering, Materials Science & Engineering, or Civil & Environmental Engineering who have an interest in molecular aspects of Biomedical Engineering. The CMBT track prepares students for careers in bio/pharmaceutical, medical diagnostics, biosensors, drug delivery, and biological aspects of environmental engineering.

requirements

In addition to the Biomedical Engineering core courses, students in the CMBT Track must take the following combination of courses:

- One (1) CMBT Gateway course
- One (1) **Required** CMBT Elective
- Two (2) other Electives (either one of the two options)
 1. One (1) CMBT Elective (either **Required** or **Additional**) and one (1) **Restricted** Elective
 2. Two (2) CMBT Electives (either **Required** or **Additional**)

CMBT Gateway Course

03-231 Biochemistry I (9 units) [#] - Fall

03-232 Biochemistry I (9 units) [#] - Spring

[#]Note that only 03-232 satisfies Chemistry Engineering course requirements, either 03-231 or 03-232 satisfies Materials Science & Engineering requirements.

CMBT Electives

Required CMBT Electives (must take at least one of the following)

42-620	Engineering Molecular Cell Biology	12
42-623	Cellular and Molecular Biotechnology	9
42-624	Biological Transport and Drug Delivery	9

Additional CMBT Electives

03-240	Cell Biology- Spring	9
42/06-622	Bioprocess Design- Spring, intermittent	9
42-643	Microfluids- Spring, intermittent	12
42-645/24-655	Cellular Biomechanics- Intermittent	9
42-646/24-657	Molecular Biomechanics- Spring, every other year	9
42-698	Special Topics-B Stem Cell Engineering - Spring, every other year	9
42-699	Special Topics-N Applied Nanoscience and Nanotechnology -Fall	12

Some Special Topics, newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives.

Restrictive Elective Courses (choose at most one)

42-698	Special Topics-A Bioinstrumentation - Fall	9
42-698	Special Topics-C Introduction to Biomedical Signal Processing - Fall	9
42-698	Special Topics-D Engineering in Medicine - Fall	9
42-698	Special Topics-E Surgery for Engineers- Spring	9
42-698	Special Topics-F Technological Innovation in Biomedical Engineering - Fall	9
42-698	Special Topics-H Systems Modeling and Analysis for Biomedical Engineering- Fall	9
42-699	Special Topics-G Computational Methods in Biomedical Engineering - Spring	12

42-x00	BME Research *	Var.
39-500	Honors Research Project *	Var.

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 Honors Research Project) must be on a BME topic supervised or co-supervised by a BME faculty member and conducted for 9 or more units of credit.

Sample schedules can be found on the CMBT (<http://www.bme.cmu.edu/uprog/cmbt.html>) page on the BME website.

General Biomedical Engineering (GBME) Track

The GBME track provides broader education in biomedical engineering than other tracks. It is aimed at students who intend on pursuing medical or graduate school and desire a general coverage of biomedical engineering with maximal flexibility in course selection. Students are strongly encouraged to consult the advisor(s) and tailor the electives according to their career plan.

Requirements

In addition to the Biomedical Engineering core requirements, students must fulfill the following requirements.

- One (1) Gateway Course listed for BMEC, BMTE, BSIP, or CMBT track.
- Three (3) Electives from BMEC, BMTE, BSIP, or CMBT track, or from other 42-6xx courses.

Some Special Topics, newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives.

** The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 Honors Research Project) must be on a BME topic supervised or co-supervised by a BME faculty member and conducted for 9 or more units of credit. Students may count EITHER 42-x00 BME Research OR 39-500 Honors Research Project (with BME supervision) OR 42-698-E Surgery for Engineers as a track elective. Students may count **EITHER** Surgery for Engineers 42-698-E **OR** Biomedical Engineering Research project, but not both, as one track elective.

Self-Designed Biomedical Engineering (SBME) Track

The SBME track is aimed at helping highly motivated students who have a strong sense of career direction that falls beyond the scope of regular Biomedical Engineering tracks. Students are allowed to design the "track" portion of the curriculum in consultation with the faculty. Example themes include medical robotics, neural engineering, or computational biomedical engineering.

The SBME track is fundamentally different from the GBME track. While the GBME track builds the breadth and may include only courses that are already associated with the four other defined tracks, the SBME track allows students to choose courses relevant to the theme from across the University.

Requirements

In addition to the Biomedical Engineering core requirements, students must take four elective courses of at least 9 units each. These elective courses must form a coherent theme that is relevant to biomedical engineering. In addition, at least one of the elective courses must be judged by the Biomedical Engineering Undergraduate Affairs Committee to have substantial biological or medical content.

Students may count EITHER Surgery for Engineers 42-698-E OR Biomedical Engineering Research project (42-x00), but not both, as one track elective. The research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 Honors Research Project) must be on a biomedical engineering topic supervised or co-supervised by a core or courtesy Biomedical Engineering faculty member and for 9 or more units.

Petition Procedure

1. Students wishing to pursue a self-designed track should first consult with the Biomedical Engineering Undergraduate Affairs Committee. Contacts for the Committee are Prof. Robert Tilton (<http://www.bme.cmu.edu/people/faculty4.html#Tilton>) (committee chair), and Prof. Conrad Zapanta (<http://www.bme.cmu.edu/people/faculty4.html#Zapanta>) (Biomedical Engineering Associate Head).

www.bme.cmu.edu/people/faculty4.html#Zapanta) (Biomedical Engineering Associate Head).

2. A SBME track proposal must be submitted electronically as a Word document to Prof. Conrad Zapanta (<http://www.bme.cmu.edu/people/faculty4.html#Zapanta>) at least three weeks prior to Pre-Registration during the spring of the sophomore year. The proposal must include:

- The four courses of the designed track, including catalog descriptions and when these courses are expected to be taken.
- A justification of how these courses form a coherent theme relevant to biomedical engineering.
- Two alternative courses that may substitute for one of the proposed courses, in case the original course is not available.

3. Once approved, the student must sign an agreement listing the theme and the four courses comprising the SBME track.

4. In the event that issues beyond the student's control, such as course scheduling or cancellation, prevent the student from completing the approved course plan, the student may petition the Biomedical Engineering Undergraduate Affairs Committee to

- Substitute a course with another course that fits the approved theme, OR
- Move to the GBME track. The student must complete one of the regular track Gateway courses, otherwise completed SBME courses may count toward GBME requirements.

Minor in Biomedical Engineering

Conrad M. Zapanta, Ph.D.

www.bme.cmu.edu

Campus Office for Student Affairs: Doherty Hall 2100

The minor program is designed for engineering students who desire exposure to biomedical engineering but may not have the time to pursue the Biomedical Engineering additional major. The program is open to students of all colleges and is popular among science majors. In conjunction with other relevant courses, the program may provide a sufficient background for jobs or graduate studies in biomedical engineering. Students interested in a medical career may also find this program helpful.

The Biomedical Engineering minor curriculum is comprised of three core courses and two or three electives. Students pursuing the minor may contact BME Associate Head (<http://www.bme.cmu.edu/people/staff.html#ADH>) for advice. Students interested in declaring Biomedical Engineering minor should contact either the Associate Department Head (<http://www.bme.cmu.edu/people/staff.html#ADH>) of Biomedical Engineering or the Biomedical Engineering Undergraduate Program Coordinator (<http://www.bme.cmu.edu/people/staff.html#UPC>).

Requirements

College of Engineering Students (5 courses):

03-121	Modern Biology	9
42-101	Introduction to Biomedical Engineering (co-req. or pre-req. 03-121)	12
42-202	Physiology (pre-req. 03-121 or permission of instructor)	9
xx-xxx	Elective I (>= 9 units) #	
xx-xxx	Elective II (>= 9 units) +	

Non-Engineering Students (6 courses)

03-121	Modern Biology	9
42-101	Introduction to Biomedical Engineering (co-req. or pre-req. 03-121)	12
42-202	Physiology (pre-req. 03-121 or permission of instructor)	9
xx-xxx	Elective I (>= 9 units) #	
xx-xxx	Elective II (>= 9 units) +	
xx-xxx	A second Introductory Engineering Course* or Any 42-xxx Course Numbered 42-3xx or Higher and worth at Least 9 Units	

Some Special Topics, newly offered or intermittently offered 42-xxx may be acceptable as electives. Students should consult with their advisors and petition the Biomedical Engineering Undergraduate Affairs Committee for permission to include such courses.

Notes

Elective I cannot be a required course in the student's major. It may be

1. Any track gateway, restricted elective, or track elective course selected from any of the four Biomedical Engineering tracks. See the online catalog (<http://www.bme.cmu.edu/ugprog/catalog.html>) for a listing of courses.
2. Any 42-xxx course with a 42-300 or higher number and worth at least 9 units.
3. 42-203 Biomedical Engineering Laboratory (or the cross-listed version 03-206 for students in the Health Professions Program). The course has a limited capacity and priority is given to students who have declared the Additional Major in Biomedical Engineering.**
4. One semester of 42-200 Sophomore BME Research Project, 42-300 Junior BME Research Project, 42-400 Senior BME Research Project or 39-500 CIT Honors Research Project. The project must be supervised by a core or courtesy Biomedical Engineering faculty member and for 9 or more units.

+ Elective II must be a Biomedical Engineering track gateway, track elective, or restricted Elective course that is offered by one of the Engineering Departments (06-xxx, 12-xxx, 18-xxx, 19-xxx, 24-xxx, 27-xxx or 42-xxx). The only exception is that 03-232, the biotechnology-focused version of Biochemistry taught each Spring by the Department of Biological Sciences, is also acceptable. Organic Chemistry I 09-217 is a pre-requisite of 03-232.

* Selected from 06-100 Introduction to Chemical Engineering, 12-100 Introduction to Civil and Environmental Engineering, 18-100 Introduction to Electrical and Computer Engineering, 19-101 Introduction to Engineering and Public Policy, 27-100 Engineering the Materials of the Future, or 24-101 Fundamentals of Mechanical Engineering. Note that these courses may involve co-requisites.

** Priority for enrollment in 42-203 or 03-206 will be given to students who have declared the Additional Major in Biomedical Engineering. If sufficient room in the course remains after all majors have been accommodated in a given semester, students who have declared the Biomedical Engineering Designated Minor will be given the next priority for enrollment. If space still allows, other students will be enrolled.

Full-Time Faculty

ANTAKI, JAMES F., Professor of Biomedical Engineering – Ph.D, University of Pittsburgh, 1991; .

ARMITAGE, BRUCE A., Professor of Chemistry, Biological Sciences, and Biomedical Engineering – Ph.D., University of Arizona, 1993; .

BETTINGER, CHRISTOPHER J., Associate Professor of Biomedical Engineering and Materials Science & Engineering – Ph.D., Massachusetts Institute of Technology, 2008; .

BRUCHEZ, MARCEL P., Associate Professor of Biological Sciences, Chemistry, and Biomedical Engineering – Ph.D., University of California, Berkeley, 1998; .

CAMPBELL, PHIL G., Research Professor, Institute of Complex Engineering Systems, Biomedical Engineering, Biological Sciences, Materials Science & Engineering – Ph.D., The Pennsylvania State University, 1985; .

CHASE, STEVEN M., Assistant Professor of Biomedical Engineering and Center for the Neural Basis of Cognition – Ph.D., Johns Hopkins University, 2006; .

CHOSSET, HOWIE, Professor, Robotics Institute, Biomedical Engineering, and Electrical & Computer Engineering – Ph.D., California Institute of Technology, 1996; .

COHEN-KARNI, TZAHI, Assistant Professor of Biomedical Engineering – Ph.D., Harvard, 2011; .

COOK, KEITH, Associate Professor of Biomedical Engineering – Ph.D., Northwestern University, 2000; .

DAHL, KRIS N., Associate Professor of Biomedical Engineering, Chemical Engineering, and Materials Science & Engineering – Ph.D., University of Pennsylvania, 2004; .

DOMACH, MICHAEL M., Professor of Chemical Engineering and Biomedical Engineering – Ph.D., Cornell University, 1983; .

FEDDER, GARY K., Howard M. Wilkoff Professor, Institute for Complex Engineering Systems, Biomedical Engineering, Electrical & Computer Engineering, Robotics Institute – Ph.D., University of California, Berkeley, 1994; .

FEINBERG, ADAM W., Associate Professor of Biomedical Engineering and Materials Science & Engineering – Ph.D., University of Florida, 2004; .

GALEOTTI, JOHN, Adjunct Assistant Professor of Biomedical Engineering – Ph.D, Carnegie Mellon University, 2007; .

GEYER, HARMUT, Assistant Professor, Robotics Institute and Biomedical Engineering – Ph.D., Friedrich-Schiller-University of Jena, Germany, 2005; .

HITCHENS, KEVIN, Assistant Research Professor of Biological Sciences and Biomedical Engineering – Ph.D., University of Virginia, 1997; .

HO, CHIEN, Professor of Biological Sciences and Biomedical Engineering – Ph.D., Yale University, 1961; .

HOLLINGER, JEFFREY O., Professor Emeritus of Biomedical Engineering and Biological Sciences – D.D.S. and Ph.D., University of Maryland, 1973 & 1981; .

HSIA, JIMMY, Professor of Biomedical and Mechanical Engineering – Ph.D., Massachusetts Institute of Technology, 1990; .

KAINERSTORFER, JANA M., Assistant Professor of Biomedical Engineering – Ph.D., University of Vienna, 2010; .

KELLY, SHAWN, Adjunct Assistant Professor of Biomedical Engineering – Ph.D., Massachusetts Institute of Technology, 2003; .

KOVACEVIC, JELENA, Professor and Head of Electrical & Computer Engineering, and Professor of Biomedical Engineering – Ph.D., Columbia University, 1991; .

LEDUC, PHILIP R., Professor of Mechanical Engineering, Biomedical Engineering, and Biological Sciences – Ph.D., Johns Hopkins University, 1999; .

LOESCHE, MATHIAS, Professor of Physics and Biomedical Engineering – Ph.D., Technical University of Munich, 1986; .

MANDAL, MAUMITA, Assistant Professor of Chemistry and Biomedical Engineering – Ph.D., Ctr for Cellular & Molecular Biology, Hyderabad, India, 2001; .

MCHENRY, MICHAEL E., Professor of Materials Science & Engineering and Biomedical Engineering – Ph.D., Massachusetts Institute of Technology, 1988; .

MINDEN, JONATHAN S., Professor of Biological Sciences and Biomedical Engineering – Ph.D., Albert Einstein College of Medicine, 1985; .

MOURA, JOSE M. F., Professor of Electrical & Computer Engineering and Biomedical Engineering – Ph.D., Massachusetts Institute of Technology, 1975; .

MURPHY, ROBERT F., Ray and Stephanie Lane Professor of Computational Biology and Professor of Biological Sciences, Biomedical Engineering, and Machine Learning – Ph.D., California Institute of Technology, 1980; .

OZDOGANLAR, BURAK, Associate Professor of Mechanical Engineering, Biomedical Engineering and Materials Science & Engineering – Ph.D., University of Michigan, 1999; .

PRZYBYCIEN, TODD M., Professor of Biomedical Engineering and Chemical Engineering – Ph.D., California Institute of Technology, 1989; .

RABIN, YOED, Professor of Mechanical Engineering and Biomedical Engineering – D.Sc., Technion - Israel Institute of Technology, 1994; .

RIVIERE, CAMERON N., Associate Research Professor, Robotics Institute and Biomedical Engineering – Ph.D., Johns Hopkins University, 1995; .

ROHDE, GUSTAVO K., Associate Professor of Biomedical Engineering – Ph.D., University of Maryland, 2005; .

RUSSELL, ALAN J., Highmark Distinguished Career Professor, Institute of Complex Engineering Systems and Biomedical Engineering – Ph.D., University of London, 1987; .

SCHNEIDER, JAMES W., Professor of Chemical Engineering and Biomedical Engineering – Ph.D., University of Minnesota, 1998; .

SHIMADA, KENJI, Theodore Ahrens Professor in Engineering – Ph.D., Massachusetts Institute of Technology, 1993; .

STETTEN, GEORGE D., Research Professor, Robotics Institute and Biomedical Engineering – MD/Ph.D., State University of New York Syracuse Health Center, 1991, and University of North Carolina, 2000; .

SURESH, SUBRA, Professor of Materials Science & Engineering, Biomedical Engineering, Engineering & Public Policy, and Public Policy & Management President, Carnegie Mellon University – Sc.D., Massachusetts Institute of Technology, 1981; .

TILTON, ROBERT D., Professor of Biomedical Engineering and Chemical Engineering – Ph.D., Stanford University, 1991; .

TRUMBLE, DENNIS, Adjunct Assistant Professor of Biomedical Engineering (on campus) - Ph.D., Carnegie Mellon University, 2010; .

WAGGONER, ALAN S., Professor of Biological Sciences and Biomedical Engineering - Ph.D., University of Oregon, 1969; .

WANG, YU-LI, Mehrabian Professor and Head of Biomedical Engineering - Ph.D., Harvard University, 1980; .

WASHBURN, NEWELL R. , Associate Professor of Biomedical Engineering, Chemistry, and Materials Science & Engineering - Ph.D., University of California, Berkeley, 1998; .

WEISS, LEE E., Research Professor, Robotics Institute, Biomedical Engineering, and Materials Science & Engineering - Ph.D., Carnegie Mellon University, 1984; .

WHITEHEAD, KATHRYN A, Assistant Professor of Chemical and Biomedical Engineering - Ph.D., University of California, Santa Barbara, 2007; .

YANG, GE, Associate Professor, Biomedical Engineering and Lane Center for Computational Biology - Ph.D., University of Minnesota, 2004; .

YU, BYRON, Associate Professor of Biomedical Engineering and Electrical & Computer Engineering - Ph.D., Stanford University, 2007; .

ZAPANTA, CONRAD M., Teaching Professor and Associate Head of Biomedical Engineering - Ph.D., The Pennsylvania State University, 1997; .

ZHANG, YONGJIE JESSICA, Associate Professor of Mechanical Engineering and Biomedical Engineering - Ph.D., University of Texas at Austin, 2005; .

Department of Chemical Engineering

Lorenz Biegler, Head
Office: Doherty Hall 1107

Chemical engineering is a broad discipline based on chemistry, mathematics, physics and biology that applies the principles of engineering science and process systems engineering to the development and commercialization of new products and processes. Engineering science provides experimental and theoretical models for predicting the behavior of fluid flow and heat transfer in materials and biological systems, as well as chemical reactions and mass transfers that take place in multi-component mixtures. Process systems engineering provides methodologies for the systematic design and analysis of processes, including their control, safety, and environmental impact. The department emphasizes the basic principles of engineering science and process systems engineering through problem solving, and it strives to broaden the experience of students by offering a significant number of electives, undergraduate research projects, an integrated masters degree, industrial internships and study abroad programs, all of which benefit from our strong industrial ties.

A career in chemical engineering offers challenging and well-compensated positions in a wide variety of growth industries. Graduates may supervise the operation of chemical plants, redesign chemical processes for pollution prevention, or be involved in the research and development of new products or processes in high technology areas. These activities require knowledge of chemical reactions and catalysis, separation technologies and energy recovery systems, all of which are thoroughly presented in our curriculum. In the petroleum industry, for example, our national need for fuels demands well-trained chemical engineers in catalysis. A significant number of chemical engineers are also hired by industries associated with colloids (fine particles), polymers (plastics and resins), and coatings (e.g., paint, integrated circuits). Opportunities exist in biotechnology, the computer industry, environmental firms, and consulting companies. Other examples include the processing of advanced polymeric systems, thin films for the semiconductor and data storage industry, and chip fabrication. A growing number of consulting companies hire chemical engineers to develop computer software for the simulation and real-time optimization of chemical processes, for predicting how toxic chemicals are dispersed and degraded in soils and in the atmosphere, and for evaluating the economic feasibility of industrial projects. The diversity of career opportunities arises from the depth and breadth of the curriculum. For instance, the pharmaceutical industry recruits chemical engineers who possess a combined expertise in process engineering and biochemistry/molecular biology.

The curriculum emphasizes the fundamentals of physical, chemical, and biological phenomena, mathematical modeling, exposure to biotechnology and problem solving techniques. These provide rigorous preparation for immediate employment after graduation, or a strong basis for graduate school. The depth and breadth of coursework makes chemical engineering an excellent major for students interested in either medical or business schools. Computing is integrated throughout the curriculum, and extensive use is made of mathematical modeling and simulation software in the department's Gary J. Powers Educational Computer Lab. The Robert Rothfus Laboratory and Lubrizol Analytical Laboratory feature state-of-the-art experiments that illustrate applications in safety, environmental, product development, and computerized data acquisition and control.

Educational Objectives and Outcomes

The objectives for the program are that graduates of the department will obtain employment or attend graduate school, will advance in their chosen careers, and will be productive and fulfilled professionals throughout their careers. The curriculum and programs are developed to prepare students to attain these educational objectives.

Students majoring in chemical engineering learn the science and engineering that govern chemical processing systems. Fundamental principles, problem solving, systems analysis and design, development of self-confidence, and communication skills are emphasized. Students are made aware of modern tools, industrial needs and societal issues. This combination of fundamental knowledge and skills provides a firm foundation for future learning and career growth. The goal of the department is to produce students who will become leaders in their careers. Students who complete the curriculum will have attained the following educational outcomes:

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments, as well as to analyze and interpret data

- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multidisciplinary teams
- an ability to identify, formulate, and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- a recognition of the need for, and an ability to engage in, life-long learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The department offers a number of special programs for students majoring in Chemical Engineering. In addition to the double majors offered by the College of Engineering such as Biomedical Engineering and Engineering & Public Policy, students may choose from a variety of minors in technical areas offered by the College of Engineering. Undergraduate research projects are also available in the areas of bioengineering, complex fluids engineering, environmental engineering, process systems engineering, and catalysis & surface science. Students may participate in study abroad programs during their junior year. In addition to the University program with EPFL in Switzerland and ITESM Monterey in Mexico, the department provides its own exchange programs with Yonsei University in Seoul, Korea, RWTH Aachen in Germany, and Imperial College in London, Great Britain. Students may also participate in Practical Internships for Senior Chemical Engineering Students, a one-year industrial internship program offered between the Junior and Senior years. Finally, qualified students may enroll in our Master of Chemical Engineering program. This degree is typically completed in the fifth year. However, depending on the number of advanced placement courses and course load at Carnegie Mellon, this degree could be awarded during the B.S. graduation, or after one additional semester.

Curriculum

The program in chemical engineering within the Department of Chemical Engineering is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

First Year

Fall		Units
21-120	Differential and Integral Calculus	10
76-xxx	Designated Writing/Expression Course	9
99-101	Computing @ Carnegie Mellon	3
06-100	Introduction to Chemical Engineering	12
09-105	Introduction to Modern Chemistry I	10
		44

Spring		Units
21-122	Integration and Approximation	10
xx-xxx	Introductory Engineering Elective (other than ChE)	12
33-106	Physics I for Engineering Students	12
xx-xxx	General Education Course	9
		43

Second Year

Fall		Units
21-259	Calculus in Three Dimensions	9
06-221	Thermodynamics	9
06-222	Sophomore Chemical Engineering Seminar	1
09-106	Modern Chemistry II	10
xx-xxx	Computer Sci./Physics II *	10-12
xx-xxx	General Education Course	9

39-210	Experiential Learning I	0
		38
Spring		Units
06-261	Fluid Mechanics	9
06-262	Mathematical Methods of Chemical Engineering	12
09-221	Laboratory I: Introduction to Chemical Analysis	12
xx-xxx	Physics II/Computer Sci.*	12-10
xx-xxx	General Education Course	9
39-220	Experiential Learning II	0
		42

* Computer Science/Physics II: Students should complete 15-110 Principles of Computing or 15-112 Fundamentals of Programming and Computer Science as well as 33-107 Physics II for Engineering Students by the end of the Sophomore year. The recommended sequence is 33-106 /33-107 for engineering students, however, 33-111/ 33-112 or 33-131 /33-132 will also meet the CIT Physics requirement.

For those students who have not taken 06-100 as one of the two Introductory Engineering Electives, 06-100 should be taken in the Fall Semester of the Sophomore year. The General Education Course normally taken during that semester may be postponed until the Junior year. These students should consult with their faculty advisors as soon as possible.

At the end of the Sophomore year, a student should have completed the following required basic science and computer science courses:

09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
33-106	Physics I for Engineering Students	12
33-107	Physics II for Engineering Students	12
99-10x	Computing @ Carnegie Mellon	3

Third Year

Fall		Units
06-321	Chemical Engineering Thermodynamics	9
06-322	Junior Chemical Engineering Seminar	2
06-323	Heat and Mass Transfer	9
09-217	Organic Chemistry I	9
or 09-219	Modern Organic Chemistry	
09-347	Advanced Physical Chemistry	12
xx-xxx	General Education Course	9
39-310	Experiential Learning III	0
		50

Spring		Units
06-361	Unit Operations of Chemical Engineering	9
06-363	Transport Process Laboratory	9
06-364	Chemical Reaction Engineering	9
03-232	Biochemistry I**	9
xx-xxx	Unrestricted Elective	9
xx-xxx	General Education Course	9
		54

Fourth Year

Fall		Units
06-421	Chemical Process Systems Design	12
06-423	Unit Operations Laboratory	9
xx-xxx	Unrestricted Elective	9
xx-xxx	Unrestricted Elective	9
xx-xxx	General Education Course	9
		48

Spring		Units
06-462	Optimization Modeling and Algorithms	6
06-463	Chemical Product Design	6
06-464	Chemical Engineering Process Control	9
xx-xxx	Unrestricted Elective	9

xx-xxx	Unrestricted Elective	9
xx-xxx	General Education Course	9
		48

**Students pursuing a Chemical Engineering/Engineering and Public Policy double major are waived from taking the Biochemistry Elective. They will take 36-220.

Notes:

- In addition to the graduation requirement of an overall QPA of 2.0 (not counting the First Year), the Department of Chemical Engineering requires a cumulative QPA of 2.0 in all chemical engineering courses (all those numbered 06-xxx).
- Minimum number of units required for graduation: 389.
- Overloads are permitted only for students maintaining a QPA of 3.0 or better during the preceding semester.
- Electives: To obtain a Bachelor of Science degree in Chemical Engineering, students must complete 06-100 and one other Introductory Engineering Elective. There are also five Unrestricted Electives. At most, 9 units of ROTC or Physical Education can be counted toward these electives. Students must discuss choice of electives with their faculty advisors.
- Undergraduate Research: Independent research projects are available by arrangement with a faculty advisor. Many students conduct these research projects for elective credit by enrolling in 06-200, 06-300, or 06-400 (Sophomore, Junior, or Senior Research Projects) or 39-500 Honors Research Project for eligible Seniors.
- Advanced undergraduates may also take Chemical Engineering graduate courses (600+ level).

Double Major in Engineering and Public Policy (EPP)

Students may pursue a double major in Chemical Engineering and EPP. This double major is very flexible, built around Electives, Social Analysis, Probability and Statistics courses, and projects. Specific course choices should be discussed with a faculty advisor and an EPP advisor.

Double Major in Biomedical Engineering (BME)

Students may pursue a double major in Chemical Engineering and BME. Specific course choices should be discussed with a faculty advisor and a BME advisor.

Minors with a B.S. in Chemical Engineering

Chemical Engineering students are eligible for any CIT Designated Minor. Those minors that are especially well suited to Chemical Engineers include Audio Engineering, Automation and Controls, Biomedical Engineering, Colloids, Polymers & Surfaces, Electronic Materials, Environmental Engineering, Global Engineering, Manufacturing Engineering, Materials Science and Engineering, Mechanical Behavior of Materials, and Robotics.

The minor requirements may be fulfilled with electives. Other minors, such as the Supply Chain Management minor in association with the Tepper School of Business, are also available outside of CIT. These should be discussed with a faculty advisor.

Minor in Colloids, Polymers, and Surfaces (CPS)

Historically, the CPS coursework sequence has had a long-standing popularity among chemical engineering students. A detailed description of the minor can be found in the CIT Minors section of this catalog, or ask your Chemical Engineering faculty advisor, or the Director of CPS. Chemical Engineering students may use four of their electives to obtain the CPS minor. This is a sequence of closely related courses that explore the science and engineering of polymeric materials, particulates, micro-structured fluids, and interfacially engineered materials. Completion of the following five courses constitutes the CPS minor:

06-221	Thermodynamics	9
06-426	Experimental Colloid Surface Science	9
06-466	Experimental Polymer Science	9
06-607	Physical Chemistry of Colloids and Surfaces	9

06-609/09-509 Physical Chemistry of Macromolecules 9

Typically, 06-607 is taken in the spring of the Junior year, while 06-609 also known as 09-509, 06-426 and 06-466 are taken during the Senior year.

Practical Internships for Senior Chemical Engineering Students (PISCES)

Chemical Engineering students may apply in the fall of their Junior year for a salaried, one-year PISCES with a partner company. Admitted students begin their internships after completion of the Junior year. Following the internship, students return to complete their Senior year. There are several advantages of a one full-year internship, including the opportunity to gain a breadth of professional experience that is not generally possible in a shorter program, more opportunity to make important contributions to the partner company, and the opportunity to complete Senior year courses in their normal sequence with no need for curriculum rearrangements. Interested students should consult with their faculty advisors.

International Chemical Engineering Exchange Programs

Chemical Engineering students may apply during their Sophomore year to spend their Junior year at RWTH Aachen in Germany, Yonsei University in Seoul, Korea, or at Imperial College in London, Great Britain. A summer exchange program in Dortmund, Germany is also available. These exchange programs provide a great opportunity for students to obtain international experience while taking courses very similar to those offered at Carnegie Mellon. Students considering any of these programs should consult with their faculty advisors, and students considering the Aachen program in particular are advised to take at least one introductory German course before or during their Sophomore year.

Fifth Year Master of Chemical Engineering (MChE)

The CIT Integrated Masters/Bachelors (IMB) Degree program provides the opportunity for qualified undergraduate students to obtain a master's degree in Chemical Engineering with one or two extra semesters of study. The goal is to deepen our graduates' understanding of the fundamentals of chemical engineering, and to provide them with a broader set of professional skills or to expose them to other technical disciplines.

The MChE program is aimed at undergraduate students from Carnegie Mellon and candidates from other universities. Unfortunately, no financial support is available. For Carnegie Mellon students, the degree typically would be completed in their fifth year. Depending on advanced placement and semester overloads, however, CMU students can complete the degree at the time of the B.S. graduation or with one additional semester. All students must have graduate status once they have completed their B.S. degree; beyond eight semesters, degree program students must have full-time graduate student status in at least one (e.g., their final) semester whether or not they have already completed their BS degree.

Upon graduating from this program, students seek industrial positions or placement in graduate programs at other universities. Students in the MChE program may apply for the PhD program at Carnegie Mellon University via the normal application process. Their applications are considered alongside all the other applications received that year. If accepted into the PhD program, they enter it after completing the MChE degree.

A minimum of five completed semesters in residence as an undergraduate student and an overall QPA of 3.0 is required for eligibility. Taking the GRE and recommendation letters are not required. The application fee is waived for currently-enrolled undergraduate Chemical Engineering students.

The MChE program differs from the MS program because the MChE program does not require a project report or thesis.

Research and Teaching Faculty

SHELLEY ANNA, Professor of Chemical Engineering – Ph.D., Harvard University; Carnegie Mellon, 2003–.

LORENZ T. BIEGLER, University Professor and Bayer Professor of Chemical Engineering. Head of Department – Ph.D., University of Wisconsin; Carnegie Mellon, 1981–.

KRIS N. DAHL, Associate Professor of Chemical Engineering – Ph.D., University of Pennsylvania; Carnegie Mellon, 2006–.

MICHAEL M. DOMACH, Professor of Chemical Engineering – Ph.D., Cornell University; Carnegie Mellon, 1983–.

NEIL M. DONAHUE, Professor of Chemical Engineering and Chemistry – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2000–.

ANDREW J. GELLMAN, Lord Professor of Chemical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 1992–.

CHRYSANTHOS GOUNARIS, Assistant Professor of Chemical Engineering – Ph.D., Princeton University; Carnegie Mellon, 2013–.

IGNACIO E. GROSSMANN, University Dean Professor of Chemical Engineering – Ph.D., Imperial College, University of London; Carnegie Mellon, 1979–.

ANNETTE M. JACOBSON, Teaching Professor of Chemical Engineering and Director of Colloids, Polymers, and Surfaces Program – Ph.D., Carnegie Mellon; Carnegie Mellon, 1988–.

MYUNG S. JHON, Professor of Chemical Engineering – Ph.D., University of Chicago; Carnegie Mellon, 1980–.

ADITYA KHAIR, Assistant Professor of Chemical Engineering – PhD, California Institute of Technology; Carnegie Mellon, 2010–.

JOHN KITCHIN, Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 2006–.

SPYROS N. PANDIS, Research Professor of Chemical Engineering and Engineering and Public Policy – Ph.D., California Institute of Technology; Carnegie Mellon, 1993–.

DENNIS C. PRIEVE, Gulf Professor Of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 1974–.

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NIKOLAOS V. SAHINIDIS, John E. Swearingen Professor of Chemical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–.

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PAUL J. SIDES, Professor of Chemical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 1981–.

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SUSANA C. STEPPAN, Assistant Teaching Professor – PhD, University of Massachusetts; Carnegie Mellon, 2004–.

ROBERT D. TILTON, Professor of Chemical Engineering – Ph.D., Stanford University; Carnegie Mellon, 1992–.

LYNN M. WALKER, Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 1997–.

ARTHUR W. WESTERBERG, Emeritus, University Professor of Chemical Engineering – Ph.D., DIC, Imperial College, University of London; Carnegie Mellon, 1976–.

KATHRYN WHITEHEAD, Assistant Professor of Chemical Engineering – Ph.D., University of California; Carnegie Mellon, 2012–.

B. ERIK YDSTIE, Professor of Chemical Engineering – Ph.D., Imperial College, University of London; Carnegie Mellon, 1992–.

Department of Civil and Environmental Engineering

David A. Dzombak, Head
Office: Porter Hall 119-D
<http://www.cmu.edu/cee/>

The role of civil and environmental engineers, in the broadest sense, is to apply technology to meet society's needs. Civil engineers plan, design, and manage facilities used daily by the public and industry, such as buildings, airports, water supply, and waste management systems. They work at the intersection of the built, natural, and information environments. Today's civil and environmental engineers are also called upon by government and industry to provide leadership on complex technical and societal issues such as demands for infrastructure improvement in our cities, remediation of hazardous waste sites, provision of safe drinking water, and incorporation of environmental safeguards in new designs. Civil and Environmental Engineering requires broad technical training and strong communication skills because of the complexity of large projects and the interactions with engineers in other fields, lawyers, politicians, and the public. Carnegie Mellon's curriculum is intended to provide this versatility for professional practice in civil and environmental engineering or as a foundation for other professional pursuits.

The Department of Civil and Environmental Engineering offers a wide spectrum of opportunities for direct entry into the engineering profession, for graduate education in engineering, or entry into various other professions. While maintaining its emphasis on the fundamental understanding of the behavior of constructed facilities through the application of the physical sciences and mathematics, the curriculum has continually evolved in directions that exploit advances in technology. The methods of engineering design are introduced in the first year and are emphasized throughout the curriculum in both traditional and open-ended project-oriented courses. The basic undergraduate degree program leads to a B.S. in Civil Engineering. Students with a specific interest in Environmental Engineering are advised to undertake the Minor in Environmental Engineering and Sustainability.

Central to the evolution of technology and its impact on engineering practice is the increased emphasis on computer-aided engineering. Several courses on computer methods are required in the curriculum, and virtually every course offered by the department requires the use of computers in applications of either analysis or design. Our curriculum emphasizes the development of scientific inquiry with the perspective of social, economic, and institutional developments. For graduates who wish to enter directly the engineering profession in such specialties as structural engineering, construction, or environmental engineering, this approach to teaching allows application of the most advanced technological developments. Others who wish to pursue graduate study are prepared to engage in research on the highest level, either in traditional specialties or in emerging fields such as smarter infrastructure. For many years, some graduates also have found their undergraduate preparation highly suited for entry into graduate schools of business, law, and medicine.

A student may choose to concentrate in a specialty area in Civil Engineering, to pursue a minor in one of the College of Engineering designated minor programs, or to design a double major or double degree program. Sample specialty areas are described in this section. The College of Engineering designated minor programs can be found under the College of Engineering section. The double-major requirements with Biomedical Engineering and with Engineering and Public Policy are described in the curriculum specified by those departments. Other double-major programs selected by recent graduates include computer science, economics, mathematics, business, architecture, history, and foreign languages. Each student should have well-defined objectives in selecting courses leading to a specialty, a minor, or a double major. Faculty mentors and the Director of Undergraduate Programs are available to discuss students' educational goals.

Educational Objectives

The objectives of the Bachelor of Science in Civil Engineering curriculum are to develop graduates who embody the following definitions:

- Graduates distinguish themselves within their organizations as individuals able to complete both conventional and cutting-edge professional challenges related to one or more of the areas of the built, natural, and information environments;
- Graduates work for a wide range of engineering and non-engineering organizations located both in the U.S. and internationally, and work on a wide range of activities, such as academic research, government service and private sector activity; and
- Graduates are innovative, proactive, and adaptive professionals, highly engaged in their professional communities.

The Civil Engineering curriculum is intended to allow ample opportunity for students to pursue areas of personal interest. The opportunity for self-exploration requires careful advising to gain meaningful educational experiences. We believe that design and team working experiences should occur at regular intervals in the curriculum, and that graduates should have appropriate "hands on" experience in laboratories and projects. Students are encouraged to participate in research projects and to pursue study or work abroad.

The Civil Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

By the end of the B.S. program, students should have achieved the following student outcomes:

- A. an ability to apply knowledge of mathematics, science and engineering
- B. an ability to design and conduct experiments, as well as to analyze and interpret data
- C. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- D. an ability to function on multidisciplinary teams
- E. an ability to identify, formulate, and solve engineering problems
- F. an understanding of professional and ethical responsibility
- G. an ability to communicate effectively
- H. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
 - I. a recognition of the need for, and an ability to engage in lifelong learning
 - J. a knowledge of contemporary issues relevant to engineering practice
- K. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The curriculum has been designed, and is periodically evaluated and refined, to provide students instruction and experiences that lead to the development of these abilities and skills.

All students admitted to the College of Engineering are not required to declare a major until the end of the first year, and may have selected a variety of Introductory Engineering Electives and associated Restricted Technical Electives within the common foundation specified for first year engineering students. By the end of the sophomore year, a civil engineering major is expected to have completed, in addition to 12-100 Introduction to Civil and Environmental Engineering, the following Restricted Technical Electives:

09-101	Introduction to Experimental Chemistry	3
09-105	Introduction to Modern Chemistry I	10
15-110	Principles of Computing	10
21-120	Differential and Integral Calculus	10

21-122	Integration and Approximation	10
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
33-106	Physics I for Engineering Students	12
33-107	Physics II for Engineering Students	12

Appearing below is the recommended four-year program of study for the BS in civil engineering. Advising and formulation of appropriate programs is available through the department for transfer students, students with advanced placement, or students wishing to study abroad.

Curriculum

First Year

Fall		Units
12-100	Introduction to Civil and Environmental Engineering	12
21-120	Differential and Integral Calculus	10
33-106	Physics I for Engineering Students	12
99-10x	Computing @ Carnegie Mellon	3
xx-xxx	Dietrich College or CFA Course	9
		46

Spring		Units
xx-xxx	Introduction to Engineering (other than CEE)	12
21-122	Integration and Approximation	10
33-107	Physics II for Engineering Students	12
09-101	Introduction to Experimental Chemistry	3
xx-xxx	Dietrich College or CFA Course	9
		46

Sophomore Year

Fall		Units
12-212	Statics	9
21-259	Calculus in Three Dimensions	9
15-110	Principles of Computing	10
09-105	Introduction to Modern Chemistry I	10
39-210	Experiential Learning I	0
xx-xxx	Dietrich College or CFA Course	9
		47

Spring		Units
12-231	Solid Mechanics	9
12-232	Solid Mechanics Lab	3
12-271	Introduction to Computer Application in Civil & Environmental Engineering	9
21-260	Differential Equations	9
39-220	Experiential Learning II	0
xx-xxx	Dietrich College or CFA Course	9
xx-xxx	Elective 1	9
		48

* Notes: If a student takes an Introduction to Engineering course which has a co-requisite other than Physics II, the co-requisite (either 15-110 or 09-105) should be taken in the freshman year while Physics II will fill the respective slot in the sophomore year.

Since College of Engineering first year students are not required to select a major, the above curriculum is based on the assumption that a potential civil engineering student is likely to select 12-100 as one of the two Introduction to Engineering courses in the first year. Otherwise, incoming sophomores should take 12-100 in the fall in lieu of Modern Chemistry or the Dietrich College elective.

Junior Year

Fall		Units
12-301	Civil Environmental Engineering Projects	9
12-335	Soil Mechanics	9
12-336	Soil Mechanics Laboratory	3
12-355	Fluid Mechanics	9
12-356	Fluid Mechanics Lab	3
39-310	Experiential Learning III	0

xx-xxx	Dietrich College or CFA Course	9
xx-xxx	Elective 2	9
		51

Spring		Units
12-351	Environmental Engineering	9
12-352	Environmental Engineering Lab	3
27-357	Introduction to Materials Selection	6
12-358	Materials Lab	3
36-220	Engineering Statistics and Quality Control	9
xx-xxx	Elective 3	9
xx-xxx	Elective 4	9
		48

Senior Year

Fall		Units
12-401	Civil & Environmental Engineering Design	15
12-411	Project Management for Construction	9
12-421	Engineering Economics	6
xx-xxx	Dietrich College or CFA Course	9
xx-xxx	Elective 5	9
		48

Spring		Units
xx-xxx	Dietrich College or CFA Course	9
xx-xxx	Dietrich College or CFA Course	9
xx-xxx	Elective 6	9
xx-xxx	Elective 7	9
xx-xxx	Elective 8	9
		45

379 Minimum number of units required for degree:

Notes on Electives

1. One elective must be in the basic sciences, from the following list:

03-121	Modern Biology	9
12-201	Geology	9

Substitutions may be made only with the approval of the Department Head.

2. One elective course is restricted to a 600-level Civil Engineering course of at least 9 units, except 12-648 and 12-690. This Civil Engineering elective is a co-requisite for 12-401.

Specialty Areas in Civil Engineering

Students may select a set of civil engineering and technical electives in the junior and senior years that enable them to concentrate in a specialty area, if they so desire. Some examples for grouping electives into specialty areas, together with representative course selections, are indicated below. Other possible groupings may be discussed with a faculty mentor.

Advanced Infrastructure Systems

		Units
12-600	AutoCAD	3
12-631	Structural Design	12
12-636	Geotechnical Engineering	9
12-657	Water Resource Systems Engineering	9
15-211	Fundamental Data Structures and Algorithms	12
18-100	Introduction to Electrical and Computer Engineering	12
21-228	Discrete Mathematics	9
21-241	Matrices and Linear Transformations	10
		76

Environmental Engineering, Science and Management

		Units
12-629	Environmental Microbiology for Engineers	9
12-636	Geotechnical Engineering	9
12-651	Air Quality Engineering	9

12-657	Water Resource Systems Engineering	9
12-658	Hydraulic Structures	9
06-221	Thermodynamics	9
06-620	Global Atmospheric Chemistry: Fundamentals and Data Analysis Methods	9
09-510	Chemistry and Sustainability	9
24-424	Energy and the Environment	9
48-795	LEED, Green Design and Building Rating in Global Context	6
		87

Structures, Mechanics and Materials

		Units
12-600	AutoCAD	3
12-635	Structural Analysis	9
24-370	Engineering Design I: Methods and Skills	12
12-631	Structural Design	12
12-636	Geotechnical Engineering	9
21-228	Discrete Mathematics	9
21-241	Matrices and Linear Transformations	10
24-262	Stress Analysis	12
		76

Double Majors and Minors

Civil engineering students may pursue double majors and minors in a variety of subjects, taking advantage of the free elective courses for other requirements. The College of Engineering has added designated minors to promote flexibility and diversity among engineering students. Many civil engineering undergraduates pursue designated minors in such areas as Global Engineering or Environmental Engineering and Sustainability.

Co-Operative Education Program

Students in civil engineering are encouraged to undertake professional internships during summer breaks. In addition, a formal cooperative internship program is available for either Jan-Aug or May-Dec in the junior year. Students undertaking these 8-month professional internships would ordinarily graduate after an additional semester of study. Program details are available from the Career Center or the Civil and Environmental Engineering office.

Integrated B.S./M.S. Program

Interested undergraduates may plan a course of study that leads to both the BS in Civil Engineering and the MS in Civil and Environmental Engineering. This course of study will ordinarily require ten semesters of study, although advanced placement or other study may reduce this time. Students can apply appropriate units earned as undergraduates for their MS program as long as they are beyond the 379 units required for the BS in Civil Engineering degree. In the ninth semester of study, students must register in graduate status. Interested students should consult their academic advisor or the CEE department office for information about admission to the MS program.

Faculty

AMIT ACHARYA, Professor of Civil and Environmental Engineering - Ph.D., University of Illinois at Urbana - Champaign; Carnegie Mellon, 2000-.

PETER ADAMS, Professor of Civil and Environmental Engineering and Engineering and Public Policy - Ph.D., California Institute of Technology; Carnegie Mellon, 2001-.

BURCU AKINCI, Paul P. Christiano Professor of Civil and Environmental Engineering - Ph.D., Stanford University; Carnegie Mellon, 2000-.

MARIO BERGES, Assistant Professor of Civil and Environmental Engineering - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2010-.

JACOBO BIELAK, P.E., Hamerschlag University Professor of Civil and Environmental Engineering - Ph.D., California Institute of Technology, P.E.; Carnegie Mellon, 1978-.

LAWRENCE G. CARTWRIGHT, P.E., Professor Emeritus of Civil and Environmental Engineering and Director of the Civil Engineering

Laboratories - M.S., Carnegie Mellon University, P.E.; Carnegie Mellon, 1977-.

SARAH J. CHRISTIAN, P.E., Assistant Teaching Professor, Civil and Environmental Engineering - Ph.D., Stanford; Carnegie Mellon, 2015-.

JARED L. COHON, President Emeritus, Carnegie Mellon University, University Professor of Civil and Environmental Engineering and Engineering and Public Policy - Ph.D., Massachusetts Institute of Technology, P.E.; Carnegie Mellon, 1997-.

KAUSHIK DAYAL, Associate Professor of Civil and Environmental Engineering - Ph.D., California Institute of Technology; Carnegie Mellon, 2008-.

DAVID A. DZOMBAK, Department Head and Hamerschlag University Professor of Civil and Environmental Engineering - Ph.D., Massachusetts Institute of Technology, P.E.; Carnegie Mellon, 1989-.

SUSAN FINGER, Professor of Civil and Environmental Engineering - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1989-.

JAMES H. GARRETT, P.E., JR., Dean, College of Engineering and Thomas Lord Professor, Civil and Environmental Engineering - Ph.D., Carnegie Mellon University, P.E.; Carnegie Mellon, 1990-.

KELVIN GREGORY, Associate Professor of Civil and Environmental Engineering - Ph.D., University of Iowa; Carnegie Mellon, 2006-.

CHRIS T. HENDRICKSON, Hamerschlag University Professor of Civil and Environmental Engineering - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1978-.

ATHANASIOS KARAMALIDIS, Associate Research Professor of Civil and Environmental Engineering - Ph.D., Democritus University of Thrace; Carnegie Mellon, 2010-.

XUESONG (PINE) LIU, Research Assistant Professor - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2015-.

GREGORY LOWRY, Walter J. Blenko, Sr. Professor of Civil and Environmental Engineering - Ph.D., University of Illinois; Carnegie Mellon, 2002-.

H. SCOTT MATTHEWS, Professor of Civil and Environmental Engineering and Engineering and Public Policy - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2001-.

MEAGAN S. MAUTER, Assistant Professor, Civil and Environmental Engineering and Engineering and Public Policy - Ph.D., Yale University; Carnegie Mellon, 2015-.

FRANCIS C. MCMICHAEL, Professor Emeritus, Civil and Environmental Engineering and Engineering and Public Policy - Ph.D., California Institute of Technology; .

DAVID NAKLES, Professor of the Practice, Civil and Environmental Engineering - Ph.D., Carnegie Mellon; .

HAE YOUNG NOH, Assistant Professor of Civil and Environmental Engineering - Ph.D., Stanford University; Carnegie Mellon, 2013-.

IRVING J. OPPENHEIM, P.E., Professor of Civil and Environmental Engineering and Architecture - Ph.D., Cambridge University, P.E.; Carnegie Mellon, 1972-.

MATTEO POZZI, Assistant Professor of Civil and Environmental Engineering - Ph.D., University of Trento, Italy; Carnegie Mellon, 2012-.

ZHEN (SEAN) QIAN, Assistant Professor, Civil and Environmental Engineering - Ph.D., University of California, Davis; Carnegie Mellon, 2015-.

CONSTANTINE SAMARAS, Assistant Professor, Civil and Environmental Engineering - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2014-.

MITCHELL J. SMALL, H. John Heinz Professor, Civil and Environmental Engineering and Engineering and Public Policy - Ph.D., University of Michigan; Carnegie Mellon, 1982-.

JAMES M. THOMPSON, P.E., Assistant Teaching Professor - Ph.D., Lehigh University; Carnegie Mellon, 2012-.

JEANNE VANBRIESEN, P.E., Duquesne Light Company Professor of Civil and Environmental Engineering - Ph.D., Northwestern University; Carnegie Mellon, 1999-.

Department of Electrical and Computer Engineering

Department of Electrical and Computer Engineering
Jelena Kovačević, Head
Diana Marculescu, Associate Head

<http://www.ece.cmu.edu/>

The field of electrical and computer engineering encompasses a remarkably diverse and fertile set of technological areas, including analog and digital electronics, computer architecture, computer-aided design and manufacturing of VLSI/ULSI circuits, intelligent robotic systems, computer-based control systems, telecommunications and computer networking, wireless communication systems, signal and information processing and multimedia systems, solid state physics and devices, microelectromechanical systems (MEMS), electromagnetic and electromechanical systems, data storage systems, embedded systems, distributed computing, mobile computing, real-time software, digital signal processing, and optical data processing. The extraordinary advances in the field during the last fifty years have impacted nearly every aspect of human activity. These advances have resulted not only in advanced computer systems but also in consumer products such as “smart” cars, programmable dishwashers and other home appliances, cell phones and mobile computing systems, video games, home security systems, advanced medical systems for imaging, diagnosis, testing and monitoring. Systems and products such as these serve to enhance our quality of life and have also served as the basis for significant economic activity. In short, the field of electrical and computer engineering has become central to society as we know it.

The Department of Electrical and Computer Engineering at Carnegie Mellon is actively engaged in education and research at the forefront of these new technologies. Because of the diverse and broad nature of the field and the significant growth in knowledge in each of its sub areas, it is no longer possible for any single individual to know all aspects of electrical and computer engineering. Nevertheless, it is important that all electrical and computer engineers have a solid knowledge of the fundamentals with sufficient depth and breadth. Society is placing increasing demands on our graduates to try their skills in new contexts. It is also placing increasing value on engineers who can cross traditional boundaries between disciplines, and who can intelligently evaluate the broader consequences of their actions. Our curriculum is designed to produce world-class engineers who can meet these challenges.

Educational Outcomes and Objectives

The B.S. in Electrical and Computer Engineering is a broad and highly flexible degree program structured to provide students with the smallest set of constraints consistent with a rich and comprehensive view of the profession. It is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. Students are encouraged and stimulated to explore multiple areas of theory and application. The Faculty of Electrical and Computer Engineering have adopted the following outcomes from ABET and have established the following objectives for the B.S. in Electrical and Computer Engineering curriculum:

Educational Outcomes

1. An ability to apply knowledge of mathematics, science and engineering.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
3. An ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
4. An ability to function in multi-disciplinary teams.
5. An ability to identify, formulate and solve engineering problems.
6. An understanding of professional and ethical responsibilities.
7. An ability to communicate effectively.
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
9. A recognition of the need for, and an ability to engage in life-long learning.
10. A knowledge of contemporary issues.

11. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

ECE Education Objectives

The ECE program objectives are shown below. They represent our vision for what our students will be doing in their engineering careers five years after they have graduated. The principal behaviors we seek to foster in our students are *expertise*, *innovation* and *leadership*. Our graduates will be:

Experts

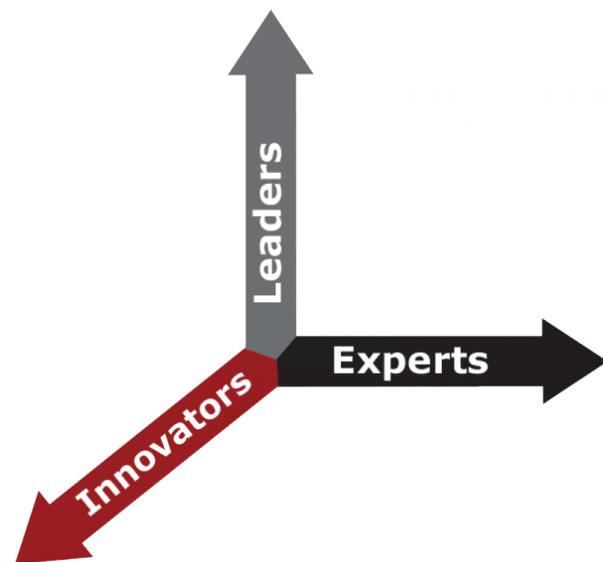
- They will solve problems by applying ECE fundamentals
- Their solutions will reflect depth of understanding in their sophistication.
- Their solutions will reflect breadth of understanding by drawing on multiple disciplines.

Innovators

- They will demonstrate creativity in their engineering practice.
- They will consider holistic systems-oriented approaches in their designs.
- They will think strategically in their planning and execution.

Leaders

- They will take initiative, and demonstrate resourcefulness.
- They will collaborate in multidisciplinary teams.
- They will be leaders in their organizations, their profession and in society.



Three dimensions of objectives for our graduates.

Curriculum Overview

Minimum number of units required for degree: 379 units.

In addition to the Carnegie Institute of Technology general education and freshman year requirements (143 units), the B.S. in Electrical and Computer Engineering requires 15-122 Principles of Imperative Computation (10 units), Physics II (12 units), two math or science electives (18 units), a Probability and Statistics course (9 units), 109 units of Electrical and Computer Engineering coursework, and 2 math co-requisites (21 units). The remaining units needed to reach the 379 required to graduate are Free Electives (57 units).

The Electrical and Computer Engineering coursework is divided into the categories of Core, Area Courses, Coverage, and Capstone Design.

The Core consists of five courses (18-100 Introduction to Electrical and Computer Engineering, 18-220 Electronic Devices and Analog Circuits, 18-240 Structure and Design of Digital Systems, 18-213 Introduction to Computer Systems, and 18-290 Signals and Systems). There are also two math co-requisites (18-202 and 21-127) and Physics II that are required co-requisites for the core. These courses provide the fundamental knowledge-base upon which all other electrical and computer engineering courses are built. 18-100 is generally taken during the freshman year, while the remaining courses in the Core are started in the sophomore year. The core courses are ideally completed by the end of the junior year (The department strongly recommends that students not take more than two core courses in the same semester). Although the core courses (and their co-requisites) may be taken in any order, students generally first take the course in their primary area of interest. This gives added flexibility to later course selection in related areas.

Students are also required to complete a seminar course during the fall semester of the sophomore year. This course, 18-200 Emerging Trends in Electrical and Computer Engineering, introduces students to the many areas within ECE and helps them decide which areas are of primary interest to them.

To satisfy the ECE Area Courses Requirement, at least two Area courses must be completed from one of the following five principal areas in ECE (24 units):

- *Device Sciences and Nanofabrication*: Solid State Physics, Electromagnetic Fields and Waves, Magnetics, Optics, etc.;
- *Signals and Systems*: Digital Signal Processing, Communication Systems, Control Systems, etc.;
- *Circuits*: Analog and Digital Circuits, Integrated Circuit Design, etc.;
- *Computer Hardware*: Logic Design, Computer Architecture, Networks, etc.; and
- *Computer Software*: Programming, Data Structures, Compilers, Operating Systems, etc.

One additional course from a second area must be taken (12 units)

For Coverage any additional ECE course(s) can be taken or an approved Computer Science course (see the ECE website for the list of approved Computer Science courses) totaling at least 12 units.

Finally, all students are required to take a Capstone Design course. In the Capstone Design courses, numbered 18-5XX, students participate in a semester-long design project with teams of other students. Students learn project management skills, make oral presentations, write reports, and discuss the broader social and ethical dimensions of ECE. Current Capstone Design courses are listed on the ECE Department website (<http://www.ece.cmu.edu/programs-admissions/bachelors/academic-guide>).

B.S. Curriculum

Minimum number of units required for degree: 379

For detailed information and regulations of the curriculum along with the degree requirements and the most recent version of the ECE curriculum and course descriptions, please refer to the ECE Home Page: <http://www.ece.cmu.edu/>

University Requirement

99-101	Computing @ Carnegie Mellon	3
or 99-102	Computing @ Carnegie Mellon	

CIT Requirements (see CIT section of the catalog for specifics (p. 115)):

CIT General Education	72	
Two semesters of calculus	20	
33-106	Physics I for Engineering Students ¹	12

One other introductory engineering course (generally taken during the freshman year)	12
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¹33-106/107 is the recommended sequence for engineering students, although 33-111/112 or 33-131/132 would also meet the CIT Physics requirement.

Specific ECE requirements:

One Introduction to Electrical and Computer Engineering course (generally taken during the freshman year)

18-100	Introduction to Electrical and Computer Engineering	12
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One ECE Seminar, taken during the fall of the sophomore year

18-200	Emerging Trends in Electrical and Computer Engineering	1
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Four ECE core courses, three with math co-requisites

18-220	Electronic Devices and Analog Circuits	12
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33-107	Physics II for Engineering Students (co-requisite to 18-220)	12
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18-290	Signals and Systems	12
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18-202	Mathematical Foundations of Electrical Engineering (co-requisite to 18-220 and 18-290)	12
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18-240	Structure and Design of Digital Systems	12
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21-127	Concepts of Mathematics (co-requisite to 18-240)	10
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18-213	Introduction to Computer Systems	12
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Two Area Courses from 1 of the 5 Areas within ECE	24
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One additional Area Course from a second Area	12
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One Coverage Course (any additional ECE course or Approved CS course as listed on the ECE web site)	12
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One Capstone Design Course (any 18-5xx course)	12
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Other ECE Requirements:

15-112	Fundamentals of Programming and Computer Science	12
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15-122	Principles of Imperative Computation	10
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Two Math/Science electives	18
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36-217	Probability Theory and Random Processes	9
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or 36-225	Introduction to Probability Theory	
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Free Electives	56
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The math/science requirement can be satisfied with any course from The Mellon College of Science or The Department of Statistics except for: 100-level courses in Mathematics or Statistics, and courses designed for non-science or engineering majors, such as (but not limited to) 09-103, 09-104, 21-257, 33-124, 36-201, 36-202, 36-207 or 36-208. Although shown in the Junior and year, these courses may be taken at any time. Mathematics courses of particular interest to students in ECE are:

21-228	Discrete Mathematics	9
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21-241	Matrices and Linear Transformations	10
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21-259	Calculus in Three Dimensions	9
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21-260	Differential Equations	9
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[56 units]Free Electives

A Free Elective is defined as any graded course offered by any academic unit of the university (including research institutes such as the Robotics Institute (<http://www.ri.cmu.edu>) and the Software Engineering Institute (<http://www.sei.cmu.edu>)). A total of at least 56 units of Free Electives must be taken.

Up to 9 units of ROTC and Physical Education courses or other courses taken as Pass/Fail may also be used toward Free Electives.

Transfer of courses from other high-quality universities may be accepted through submission of the Transfer Credit Request form on the CIT web page (http://www.cit.cmu.edu/current_students/services/transfer_credit.html).

The large number of units without categorical constraints provides the student, in consultation with their Faculty Advisor or Mentor, with the flexibility to design a rich educational program.

Sample Curriculum

The following table shows a possible roadmap through our broad and flexible curriculum:

Freshman		Sophomore	
Fall	Spring	Fall	Spring
18-100 Introduction to Electrical and Computer Engineering	Introductory Engineering course	18-200 Emerging Trends in Electrical and Computer Engineering	18-2xx ECE Core course
15-112 Fundamentals of Programming and Computer Science	33-106 Physics I for Engineering Students	18-2xx ECE Core Course	21-127 Concepts of Mathematics or 18-200 Mathematical Foundations of Electrical Engineering
21-120 Differential and Integral Calculus	21-122 Integration and Approximation	18-202 Mathematical Foundations of Electrical Engineering or 21-127 Concepts of Mathematics	15-122 Principles of Imperative Computation
76-101 Interpretation and Argument	First-year General Education course	33-107 Physics II for Engineering Students	36-217 Probability Theory and Random Processes
99-101 Computing @ Carnegie Mellon		General Education course	General Education course
		39-210 Experiential Learning I	39-220 Experiential Learning II

Junior		Senior	
Fall	Spring	Fall	Spring
18-2xx ECE Core course	18-2xx ECE Core course	18-xxx ECE Coverage course	18-5xx ECE Capstone Design course
18-3xx/4xx ECE Area 1 course (first course in Area)	18-3xx/4xx ECE Area course (either 2nd course from Area 1 or the Area 2 course)	18-3xx/4xx ECE Area course (either 2nd course from Area 1 or the Area 2 course)	General Education course
General Education course	Math/Science Elective 2	General Education course	Free Elective
Math/Science elective 1	General Education course	Free Elective	Free Elective
Free Elective	Free Elective	Free Elective	Free Elective
39-310 Experiential Learning III			

Notes on the Curriculum

Policy on ECE Coverage Courses with Fewer than 12 Units

The basic curriculum requirements for Area courses, Coverage and Capstone Design are stated in terms of courses rather than units. The nominal total of 60 units for these categories is determined by assuming that each course is 12 units. In the event that courses with fewer than 12 units are used to satisfy some or all of these requirements, additional courses from the ECE coverage lists must be taken until the total units in ECE courses beyond the core meets or exceeds 60 units. Any ECE coverage course is acceptable, and any excess units beyond the required 60 may be counted as free elective credit.

QPA Requirement and Overload Policy

An overload is defined as any schedule with more than 54 units in one semester. A student will only be permitted to overload by 12 units if he or she achieved a QPA of at least 3.5 out of 4.0 in the previous semester he or she is registering for, or if his or her overall QPA is at least a 3.5.

Pass/Fail policy

Up to 9 units of ROTC and Physical Education courses or other courses taken as Pass/Fail may be used toward Free Electives. ECE core courses may not be taken as pass/fail. ECE project-based courses (including capstone design courses) may not be taken pass/fail. No ECE requirements may be fulfilled using a pass/fail course (except for 99-10x and 18-200)

Other Graduation Requirements

To be eligible to graduate, undergraduate students must complete all course requirements for their program with a cumulative Quality Point Average of at least 2.0. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. Students are encouraged to confirm all graduation requirements with their academic advisor.

CIT has the following requirement for graduation. "Students must complete the requirements for their specified degrees with a cumulative quality point

average of 2.00 or higher for all courses taken after the freshman year [this is the CIT QPA on the Academic Audit].

In addition, a student is expected to achieve a cumulative quality point average of 2.00 in a series of core departmental courses." In ECE, this means that the student must complete 18-100 Introduction to Electrical and Computer Engineering, ECE Core, Area Courses, Coverage, and Capstone Design courses with a minimum QPA of 2.0 to graduate. When more than one possibility exists for meeting a specific requirement (e.g., Area Course), the courses used for calculating the ECE QPA will be chosen so as to maximize the QPA. Similarly, when an ECE course is retaken, the better grade will be used in the computation of the minimum QPA for the ECE QPA requirement to graduate.

Other Opportunities in ECE

ECE Cooperative Education Program

The ECE Co-Op is a unique 8-month contiguous extended internship experience in which ECE students with a minimum QPA of 3.0 may opt to participate in. Students typically engage in this option in the spring semester of their junior year, from January through August. A May through December option is also available. Students who engage in this program typically graduate in 4.5 academic years (but still eight semesters). Eligible students interested in participating should contact their advisor in the ECE Undergraduate and Graduate Programs Office. Students are required to submit a formal application consisting of a transcript, a resume, and a one-page statement of purpose including an academic plan. Students then work with the Career Center to find a Co-Op position. Once a Co-Op position is found, a Co-Op job description is required from the employer, to be approved by the ECE Undergraduate Office.

While on the Co-Op assignment, the students are participating in a recognized CIT educational program, retaining their full-time student status, akin to our students who study abroad in established exchange programs (such as NCTU or EPFL) for one or two semesters.

Upon returning to Carnegie Mellon, the students are required to submit for approval the following two documents to the ECE Undergraduate Office: a three to five page technical report of the Co-Op work, and a one page assessment and evaluation of the Co-Op experience. Students may obtain more detailed information through the department, the Career Center in the University Center, or online at <http://www.ece.cmu.edu/programs-admissions/bachelors/index.html>

Integrated M.S./B.S. Degrees Program

The Integrated Master's/Bachelor's program (otherwise known as the IMB program) is an exciting opportunity for students who excel academically to achieve not just a Bachelor's degree in ECE, but also a Master's degree through our Professional MS degree program-without needing to apply separately. This means no application fee, and no need to take the GRE (Graduate Record Exam). In order to be awarded the MS degree in the IMB program, the student must also earn their BS degree, either simultaneously with the MS degree or at least one semester prior to the awarding of the MS degree. If a course is eligible for the MS degree but must be used to complete the BS degree, the BS degree takes priority over the MS degree.

If a student is at least a 2nd semester junior, has completed at least 270 units and has at least an overall 3.00 QPA, he or she is guaranteed admission into the Professional MS degree in ECE through the IMB program. To be officially admitted, the student must complete the IMB program form.

If a student does not meet the exact overall 3.00 QPA requirement, he or she is eligible to petition for his or her admission into the IMB program during his or her senior year. Students may obtain the petition forms through a meeting with their assigned academic advisor.

Professional MS Degree Requirements:

Please see the ECE web site for the requirements for the Professional MS degree (<http://www.ece.cmu.edu/programs-admissions/masters/ms-requirements.html>). For students in the ECE IMB program, all requirements for the Professional MS degree are in addition to the requirements for the BS in ECE. No requirements for the MS degree may be used in any way toward the BS degree, including minors, additional majors or dual degrees.

Residency requirements and financial impacts:

Once a student in the IMB program has completed all of the requirements for the BS degree, he or she may become a graduate (Masters) student. To do this, the student's undergraduate degree is certified, and that student officially graduates with the BS degree. Once a student's undergraduate degree has been certified, no more courses may then be applied toward the BS degree. This includes courses toward minors and additional majors, although students pursuing an undergraduate dual degree with another department may still continue to apply additional coursework toward that second degree.

If a student takes more than 8 semesters to complete both the BS and MS degrees, then he or she must be a graduate student for at least one semester before graduating with the MS degree.

To determine the most appropriate time for an undergraduate student to become a graduate student, he or she should consult with Enrollment Services to understand how becoming a graduate student will affect financial aid, and with his or her academic advisor to determine a course schedule. When a student is a graduate student through the IMB program, the department is able to provide some financial assistance through Teaching Assistantships. Please see the ECE web site for further information regarding this financial assistance.

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ELIAS TOWE, Professor of Electrical and Computer Engineering; Albert and Ethel Grobstein Memorial Professor of Materials Science and Engineering; Director, CNXT - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2001-.

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ROBERT WHITE, Emeritus, University Professor Emeritus of Electrical and Computer Engineering and Engineering and Public Policy - Ph.D., Stanford University; Carnegie Mellon, 1993-.

JEANNETTE WING, President's Professor of Computer Science; Professor of Electrical and Computer Engineering - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1985-.

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JINGXI ZHU, Assistant Professor of the Joint Institute of Engineering; Visiting Professor of Electrical and Computer Engineering - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2014-.

Courtesy Appointment

BOB IANNUCCI, Associate Dean and Director of Silicon Valley Campus, Distinguished Service Professor - PhD, Massachusetts Institute of Technology; .

Department of Engineering and Public Policy

Douglas C. Sicker, Head
Deanna H. Matthews, Associate Department Head for Undergraduate Affairs
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The Department of Engineering and Public Policy (EPP) is a unique department that works on problems at the interface between technology and society. Society is largely responsible for setting the goals and framing the problems that engineers and scientists work on. However, technologies designed by engineers and scientists profoundly change the societies in which they operate. Technology has enabled a healthier, richer, and more productive society. At the same time, technology has contributed to the creation of many of the more serious problems our society faces.

Technology can help us build a happier, freer, and more fulfilling life, while maintaining risks and undesirable impacts at acceptable levels. But that does not happen automatically. It takes careful hard work by people who understand both technology and the society in which they live. In order to do their jobs responsibly and well in today's world, engineers and scientists must develop an understanding of the interface between technology and society and a command of the skills necessary to work at that interface. The undergraduate degree programs of the Department of Engineering and Public Policy (EPP) have been designed to allow undergraduate students at Carnegie Mellon University to add this important dimension to their traditional engineering or science education. EPP additional major graduates, for the most part, will enter traditional careers, but will carry with them a set of insights and skills that will help them to better deal with issues in technology and policy, and better exercise their ethical and social obligations as practicing professionals.

Overview of the Undergraduate Programs in EPP

The undergraduate additional major programs in EPP combines the strong foundation in mathematics and physical sciences, and the development of engineering or science skills with a rigorous preparation in the analysis of social and political problems. The curriculum includes subject matter which is not part of traditional technical or social science curricula, but which contains elements of each. Students complete courses in four core areas: economics, statistics, decision-making, and communication. Breadth is achieved through EPP Technology-Policy elective courses. Finally, students apply their skills in a project preparatory course and two interdisciplinary problem-solving projects. Problem areas for these projects are chosen from local, state, and national situations, and include such topics as industrial automation and robotics, environmental control, telecommunication and computer technologies, product safety, and energy systems. Students from several CMU colleges enroll in these projects courses exposing EPP additional majors to working in truly interdisciplinary situations. Examples of past project course topics (http://www.epp.cmu.edu/undergraduate/project_courses.html) and final reports are available.

Additional Major in Engineering and Public Policy

The EPP department offers an additional major in Engineering and Public Policy (EPP) with each of the five traditional engineering departments in the engineering college. The engineering double major leads to a fully accredited engineering degree that prepares students for traditional technical careers. EPP additional major engineers are not educated to be a different kind of engineer. Rather, their education is intended to enable them to be better, more socially responsible engineers in the traditional technical fields.

Additional Major in Science, Technology, and Public Policy

Beginning in Fall 2014, we also offer an additional major in Science, Technology and Public Policy (STPP) for students outside of the engineering college who are earning a B.S. degree. This includes students in the Mellon College of Science, the School of Computer Science, and select majors in the Dietrich College. Similar to the additional major in Engineering and Public Policy, the additional major in Science, Technology and Public Policy is meant to broaden the perspectives on a student's primary major and provide additional skills for future careers.

Minor in Technology and Policy

The department also offers a minor in Technology and Policy for non-engineering majors. The Technology and Policy minor exposes students

to issues at the interface of science, technology, and society, and how interdisciplinary approaches are needed to solve complex problems.

Career Options with EPP Additional Majors

Students who select one of the EPP additional majors graduate with a regular accredited engineering degree or complete science degree, and thus have all of the options for traditional technical careers as their single major classmates. A large portion of our double major students pursue traditional technical careers after graduation.

The advantage of the additional major is the added set of skills and perspectives, which allow a graduate of the program to improve the quality, sensitivity, and social responsiveness of their work, and the work of their colleagues. Employers recognize these skills and often view our graduates as more attractive for a traditional engineering position. Firms contact the EPP department every year to recruit EPP graduates because of their satisfaction with the knowledge and skills acquired by EPP students.

The additional major also opens up a collection of other options that are not available to most technical graduates. These include jobs in policy analysis in federal, state, and local government or in public policy consulting firms. Alumni also pursue careers in companies to deal with issues like government regulation, environmental control, worker health and safety, product liability and safety, telecommunications policy, energy systems, and the social impact of large technological systems.

Students also choose to continue their formal education, doing graduate work in engineering, the social sciences, law, or interdisciplinary programs.

Faculty Advisors

Faculty in several departments serve as advisors and information resources to students selecting the EPP undergraduate programs. Given the interdisciplinary perspective of EPP, students may find that a faculty member outside their traditional major can provide support and guidance with EPP-related courses and career paths. The EPP Associate Department Head for Undergraduate Affairs is Deanna Matthews. Dr. Matthews can provide general academic advice and guidance for all EPP double majors. Other faculty affiliated with the undergraduate programs in EPP are:

- Civil Engineering: Peter Adams, Scott Matthews, Mitch Small
- Chemical Engineering: Meagan Mauter
- Computer Science: Lorrie Cranor
- Electrical and Computer Engineering: Jon Peha, Marvin Sirbu
- Engineering and Public Policy: Ines Azevedo, Liz Casman, Erica Fuchs, Paulina Jaramillo, Deanna Matthews, Granger Morgan
- Mechanical Engineering: Jeremy Michalek, Edward Rubin
- Material Science and Engineering: Jay Whitacre
- Social and Decision Sciences: Paul Fischbeck, Baruch Fischhoff

EPP Program Educational Objectives

Society needs engineers and scientists who understand how they impact the surrounding environment and it needs policy makers with more depth of technical expertise. EPP graduates help bridge this gap. Through required courses, carefully selected electives, and project activities, double major students in Engineering and Public Policy develop the perspectives and skills that enable students to understand and work at the interface between technology and society.

Together with the objectives of the traditional technical majors, the Engineering and Public Policy undergraduate program aims to produce graduates who:

- are leaders and innovators in their professions and communities,
- value and make use of the broader perspective and analysis skills acquired through their additional major experience on Engineering and Public Policy in the workplace and beyond.

EPP Student Outcomes

By the end of the combined B.S. programs in a traditional engineering program and the EPP program, students should have attained the following:

1. an ability to apply knowledge of mathematics, science, and engineering;
2. an ability to design and conduct experiments, as well as to analyze and interpret data;

3. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
4. an ability to function on multidisciplinary teams;
5. an ability to identify, formulate, and solve engineering problems;
6. an understanding of professional and ethical responsibility;
7. an ability to communicate effectively;
8. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
9. a recognition of the need for, and an ability to engage in life-long learning;
10. a knowledge of contemporary issues;
11. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice;

plus these additional skills:

12. an ability to demonstrate that engineering analysis alone is not sufficient to solve a "real world" societal need or problem;
13. an ability to complete an analysis of a problem that involves technical, social science/behavioral, and policy dimensions and components;
14. an ability to characterize the scale and systems level impacts of technology and public policy solutions;
15. an ability to structure unstructured problems as part of a multi-disciplinary team;
16. an ability to recognize they are appropriately trained for careers beyond traditional engineering.

Course Requirements for the Additional Major in EPP

Students pursuing an additional major in EPP must complete three sets of requirements: courses for the EPP additional major, courses for their traditional disciplinary major, and general education courses. The student should refer to the relevant sections of this catalog for the required courses in the traditional disciplinary major. The EPP additional major is designed to be completed with a traditional disciplinary major in the standard four-year time frame. However, additional units or course work may be required. Some courses for the EPP additional major may also satisfy requirements for traditional disciplinary majors or for general education courses.

Course Requirements

Course		Units
19-101	Introduction to Engineering and Public Policy	12
19-201	EPP Sophomore Seminar	1
73-100	Principles of Economics	9
36-220	Engineering Statistics and Quality Control (or other approved statistics course)	9
19-301 or 88-223 or 88-302	Decision Making Methods for EPP Decision Analysis and Decision Support Systems Behavioral Decision Making (or other approved decision science course)	9
19-325 or 76-270	Technology and Policy Writing for Lay Audiences Writing for the Professions (or other approved writing course)	9
19-351	Applied Methods for Technology-Policy Analysis	9
19-451	EPP Projects	12
19-452	EPP Projects	12
	Three EPP Technology-Policy Electives	24

Introductory Courses

19-101 Introduction to Engineering and Public Policy

19-201 EPP Sophomore Seminar

The two introductory courses prepare students for the double major experience through discussion and assessment of technology-policy interactions. 19-101 Introduction to Engineering and Public Policy may be taken as the second introductory engineering course during the first year for engineering students. 19-201 EPP Sophomore Seminar is required in addition to any corresponding seminar course in a student's traditional degree program.

Core Area Courses

73-100 Principles of Economics

36-220 Engineering Statistics and Quality Control

EPP Decision Science elective - one of the following, or other approved course:

19-301 Decision Making Methods for EPP

88-223 Decision Analysis and Decision Support Systems

88-302 Behavioral Decision Making

EPP Writing and Communications elective - one of the following, or other approved course:

19-325 Technology and Policy Writing for Lay Audiences

76-270 Writing for the Professions

The four core area courses provide the foundational skills in the social sciences that are needed for robust analysis of policy problems. 73-100 Principles of Economics should be taken as a CIT First Year General Education course. AP credit for 73-100 is accepted, but then students are encouraged to take 73-230 Intermediate Microeconomics.

36-220 Engineering Statistics and Quality Control is required for all CE, ME, and MSE students in their traditional engineering majors. ChE students will substitute 36-220 for 03-232 Biochemistry I. ECE students, who take 36-217 Probability Theory and Random Processes for their traditional engineering major, may take 36-220 or 36-226 Introduction to Statistical Inference. Students should complete the statistics requirement by the end of sophomore year. A statistics course is a prerequisite for the EPP Decision Science elective.

The EPP Decision Science elective fulfills either the CIT General Education Social Analysis and Decision Making requirement or a CIT General Education free elective. The EPP Writing and Communications course fulfills the CIT General Education Writing and Expressions requirement.

Technology-Policy Electives

- At least 3 courses of EPP Technology-Policy electives (24 units minimum)

EPP Technology-Policy Electives include courses that belong to three categories. First, EPP Technology-Policy Electives include courses that synthesize engineering analysis and social analysis perspectives and apply them to problems with substantial societal and technological components. Specific areas of interest for these courses are (1) energy, resources, and the environment, (2) risk assessment, (3) forensic engineering, (4) urban engineering, (5) information and communication technology, and (6) product engineering and design, among others. Second, EPP Technology-Policy Electives include courses that teach methods or analysis skills necessary for solving complex problems. Examples include mathematical or statistical courses related to optimization or estimation, or economics courses related to economic analysis. Finally, EPP Technology-Policy Electives include courses that provide technical background for policy relevant issues. These courses are fundamental for understanding our current engineering systems and how proposed changes can be implemented. Examples include courses on electricity systems, engine design, or atmospheric systems.

Qualifying courses for EPP Technology-Policy Electives are determined each semester. The majority of 19-xxx EPP departmental courses are considered EPP Technology-Policy Electives. Exceptions will be identified when the courses are offered. 19-301 and 19-351 are required courses for the EPP additional major and may not be used as EPP Technology-Policy electives. Courses from other departments also are acceptable as electives. Students should work with their advisors to define areas of concentration or a selection of breadth courses for the EPP Technology-Policy Electives.

Students are required to take at least three EPP Technology-Policy electives for a minimum of 24 units. Units may be added in any combination, but a maximum of one 3-unit course is permitted. Up to 9 units of research may be used with approval. Students may not use a required course from their traditional disciplinary major for these elective units. However, students may use an elective course from their traditional major requirements to meet the requirements of both their traditional engineering major and an EPP Technology-Policy elective, but the units for the course will not be double-counted toward units required for their degree. Some EPP Technology-Policy elective courses may fulfill requirements for CIT General Education categories (e.g., 19-411 Global Competitiveness: Firms, Nations and Technological Change is an I&I course), otherwise students use Free Elective units to complete this requirement.

Capstone Courses

- 19-351 Applied Methods for Technology-Policy Analysis
- 19-451 or 19-452 EPP Projects (taken twice)

The capstone courses synthesize the technical skills and knowledge from a student's traditional major with the social science skills and broad perspective of the EPP major.

19-351 Applied Methods for Technology-Policy Analysis is a preparatory course for the EPP Projects. 19-351 may be completed as a co-requisite of 19-451/19-452 EPP Projects. The course fulfills CIT General Education free elective units.

19-451/19-452 EPP Projects are taken twice by all students. EPP Projects are technology/policy projects which deal with research and development of recommendations for solving actual and critical problems currently affecting society. The students, faculty, and graduate student managers for the project are drawn from EPP, Social and Decision Sciences, and the Heinz College, and other CMU departments, and hence bring different areas of expertise to the structuring and solution of the problem. The topics for EPP Projects are drawn from diverse areas such as environmental systems and resources, public transportation, urban engineering problems, energy and fuel utilization, the interaction of law and technology, strategic materials and vulnerability of supply, technical issues in national security, and problems in automation, robotics, and communication technology. Students use Free Elective units to complete this requirement.

Notes on EPP double major requirements

Students should follow the suggested curriculum timelines for completing the math, science, and engineering course requirements of the traditional major with the exception of 36-220 which should be taken as early as possible and no later than the end of sophomore year.

All students must complete 76-101 Interpretation and Argument. Some courses as noted above may be used to fulfill requirements of general education courses. Acceptable courses for the CIT General Education requirements are maintained by the CIT Dean's Office. Students must submit a plan during their first-semester as an EPP student (usually Fall sophomore year) for these general education courses demonstrating their relevance to EPP.

Students must complete the minimum number of units as required by their traditional major for graduation. In some cases, students completing the EPP additional major may need to complete additional units to meet all requirements for the traditional major and EPP additional major.

In addition to any other graduation requirements (e.g., regarding course work, minimum QPA, pass/fail course work, etc.) of the student's traditional disciplinary major, students must earn a minimum QPA of 2.0 in all courses required for the EPP major.

Side-by-side curriculum charts (<http://www.cmu.edu/epp/prospective/undergraduate/epp-additional-major/curriculum-charts>) of the curricula for the traditional engineering majors alone versus the traditional engineering majors with the EPP double major can assist students in determining the course requirements and scheduling needed to complete the degree requirements.

A proposed semester plan is below. Students work with their faculty advisors to determine the best sequence of courses given the varied requirements in the traditional majors.

Course	Semester
19-101 Introduction to Engineering and Public Policy	First-year Spring
73-100 Principles of Economics	First-year Fall or Spring
19-201 EPP Sophomore Seminar	Sophomore Fall
36-220 Engineering Statistics and Quality Control	Sophomore Fall or Spring
EPP Writing and Communications Elective	Sophomore Fall or Spring
EPP Decision Science Elective	Junior Fall
19-351 Applied Methods for Technology-Policy Analysis	Junior Spring
3 EPP Technology-Policy Electives	Junior and/or Senior year
19-451/19-452 EPP Projects	Senior Fall and Spring

Course Requirements for the Additional Major in STPP

The requirements for the Science, Technology and Public Policy additional major are the same as those for the Engineering and Public Policy additional major. Similar to CIT-EPP students, some courses will fulfill some major requirements or "general education" requirements (e.g. 73-100 for Economics students, statistics course for most majors). Other courses will use students' elective spaces or free elective units. Core courses required for a student's major will not be allowed to double-count for Technology Policy electives, but elective courses can be selected that fulfill both major elective requirements and Technology Policy electives. Students pursuing

the STPP additional major should work with their advisors to determine how best to fit the additional major requirements into their course load.

Introductory Courses

		Units
19-101	Introduction to Engineering and Public Policy	12
19-201	EPP Sophomore Seminar	1

Core Area Courses

73-100	Principles of Economics	9
Statistics course — one of the following:		
36-220	Engineering Statistics and Quality Control	9
36-226	Introduction to Statistical Inference	9
73-407	Fundamentals of Statistical Modeling	9
or other approved statistics course		

EPP Decision Science course — one of the following:

19-301	Decision Making Methods for EPP	9
88-223	Decision Analysis and Decision Support Systems	9
88-302	Behavioral Decision Making	9
or other approved decision science course		

EPP Writing and Communications course — one of the following:

19-325	Technology and Policy Writing for Lay Audiences	9
76-270	Writing for the Professions	9
76-271	Introduction to Professional and Technical Writing	9
or other approved writing and communications course		

Technology-Policy Electives

3 courses, at least 24 units	24 minimum units
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Capstone Courses

19-351	Applied Methods for Technology-Policy Analysis	9
19-451	EPP Projects	12
or 19-452	EPP Projects	
(taken twice, 12 units each for 24 units total)		

Students may complete some of the introductory and core area courses as part of their primary major or General Education course requirements. Required courses in a primary major cannot be used to fulfill Technology-Policy electives; however, elective courses in a primary major may be able to fulfill Technology-Policy elective requirements as well.

Fifth Year M.S. program in Engineering and Public Policy

Students, regardless of whether they complete an undergraduate additional major or not, may apply for the fifth year masters program that will lead to the additional degree of Master of Science in Engineering and Public Policy. This course of study will ordinarily require two additional semesters of study beyond that required for the undergraduate degrees in the primary major and EPP double major. Some coursework towards the MS may be able to be completed during the student's senior year, however no courses taken may count for both a BS in CIT and the MS in EPP. The primary concern for scheduling and completing this integrated program is completing the core courses in the EPP graduate program, as some of these courses are taught every other academic year only. Students interested in the program must have a minimum 3.0 QPA and should contact their advisor for details on the application process and course requirements.

Minor in Technology and Policy

The department also offers a minor in Technology and Policy to non-CIT majors. This minor allows students outside of engineering to sample the EPP requirements and develop exposure and awareness to issues at the interface of science, technology, and society.

Pre-requisites: Students should have prerequisite knowledge in economics (73-100 Principles of Economics or higher level economics course) and statistics (36-202 Statistical Methods or higher level statistics course) in order to pursue the Technology and Policy Minor.

Course Requirements		Units
19-101	Introduction to Engineering and Public Policy	12
19-301	Decision Making Methods for EPP (or other approved Decision Science course)	9

or 19-351	Applied Methods for Technology-Policy Analysis	
19-451	EPP Projects	12
or 19-452	EPP Projects	
xx-xxx	Two EPP Technology-Policy Electives	18

EPP Technical Electives include courses in CIT, MCS, or SCS that address problems at the society-technology interface and the means of analyzing these issues. A list of qualifying Technology-Policy electives is assembled each semester and is available from the EPP Department. Example Technology-Policy electives include:

19-211	Ethics and Policy Issues in Computing	9
19-365	Water Technology Innovation and Policy	9
19-402	Telecommunications Technology, Policy & Management	12
19-411	Global Competitiveness: Firms, Nations and Technological Change	9
19-424	Energy and the Environment	9

Students must earn a cumulative QPA of 2.0 in all courses taken for the minor. Required courses taken for a student's primary major may not be counted toward the Technology and Policy Minor. Elective courses for a student's primary major or courses fulfilling general education requirements may be counted, however.

Details of this program are provided in the discussion of CIT minors; see Technology and Policy Minor Description (p. 126).

Bachelor of Science in Engineering and Public Policy and Master of Science in Public Policy and Management

Highly motivated and talented students can earn the EPP double major bachelor's degree, and a master's degree in the H. John Heinz College of Public Policy and Management in a five-year course of study. Students interested in the combined degree program should enroll in a standard double major program in an engineering specialty and EPP. During the third year of study, the student applies to the Heinz College for admission to the master's program; an academic record of B average or better is normally a prerequisite for admittance.

The five-year course of study is possible because of specific course load overlaps between the EPP and Heinz College programs: (1) some social analysis requirements in EPP, usually four semester courses, can be satisfied with Heinz College common core courses in economics and social science; (2) at least one project course is common and applicable to both curriculums; (3) at least one additional EPP technical elective, engineering option, or project course will be accepted for Heinz College credit following the usual request to the master's committee.

Students desiring this option should seek faculty advice and counsel in their freshman or sophomore year so that a curriculum satisfying all the degree requirements can be ensured. Contact the Associate Department Head for Undergraduate Affairs in EPP for more information. For general information on Heinz 3-1-1 programs please contact the Heinz College or refer to their website.

EPP Undergraduate/Graduate Level Courses

Many courses taught by the department (19-XXX courses) are offered to undergraduate and graduate students. These "dual level" courses are offered in two formats:

- Some courses are taught under both an undergraduate and graduate number. An example is 19-402 Telecommunications Technology, Policy & Management. In these types of courses, students who sign up under the 700-level (graduate) course number may be expected to perform the same coursework at a higher level, and/or complete additional coursework, compared to 19-4XX students. Undergraduates who choose to take the course under the graduate number will be also be expected to work at the higher expectation/coursework level.
- Other courses are taught under a 600 level number. An example is 19-688 Innovation for Energy and the Environment. These courses may be taken by undergraduates as a senior level course, or by graduate students as a graduate level course. As with dual number courses, graduate level students or undergraduates taking the course for graduate credit may be required to perform coursework at a higher level and/or complete additional coursework. Undergraduates who are taking a 600 level course for graduate credit should identify this fact to both the course instructor and to their EPP department advisor.

Students who have questions about the requirements of a specific EPP 400/700, or 600 level course, should contact the course instructor.

Other departments may have different policies regarding courses offered under both an undergraduate and graduate number, and courses offered under numbers other than the 100, 200, 300, 400, or 700 levels. Students who wish to take these courses should check with those departments for their specific policies.

Faculty

PETER ADAMS, Professor of Civil and Environmental Engineering / Engineering and Public Policy - Ph.D., Caltech; Carnegie Mellon, 2001-.

JAY APT, Professor of Technology of The Tepper School of Business / Engineering and Public Policy - Ph.D., MIT; Carnegie Mellon, 2000-.

DANIEL ARMANIOS, Assistant Professor - PhD, Stanford University; Carnegie Mellon, 2015-.

V. S. ARUNACHALAM, Collaborating Professor of Engineering and Public Policy / Materials Science and Engineering / Robotics Institute - Ph.D., Wales D.Eng. (h.c.), Roorkee;; Carnegie Mellon, 1992-.

INES LIMA AZEVEDO, Associate Professor of Engineering and Public Policy - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2009-.

MICHEL BEZY, Distinguished Service Professor of Engineering and Public Policy; Associate Director, Carnegie Mellon University in Rwanda - Ph.D., Université Catholique de Louvain; Carnegie Mellon, 2011-.

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KATHLEEN M. CARLEY, Professor of the Institute of Software Research / Social and Decision Sciences / The H. John Heinz III College / Engineering and Public Policy - Ph.D., Harvard University; Carnegie Mellon, 1984-.

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RAMAYYA KRISHNAN, Dean of The H. John Heinz III College; William W. and Ruth F. Cooper Professor of Management Science and Information Systems; Professor of Engineering and Public Policy – Ph.D., University of Texas at Austin; Carnegie Mellon, 1987–.

DEANNA MATTHEWS, Assistant Teaching Professor of Engineering and Public Policy; Associate Department Head for Undergraduate Affairs – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2001–.

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MEAGAN MAUTER, Assistant Professor of Chemical Engineering / Engineering and Public Policy – Ph.D., Yale University; Carnegie Mellon, 2012–.

JEREMY J. MICHALEK, Professor of Mechanical Engineering / Engineering and Public Policy – Ph.D., University of Michigan; Carnegie Mellon, 2005–.

M. GRANGER MORGAN, University and Lord Chair Professor of Engineering; Professor of Engineering and Public Policy / Electrical and Computer Engineering / The H. John Heinz III College – Ph.D., University of California, San Diego; Carnegie Mellon, 1974–.

SPYROS N. PANDIS, Research Professor of Chemical Engineering / Engineering and Public Policy – Ph.D., California Institute of Technology; Carnegie Mellon, 1993–.

JON M. PEHA, Professor of Engineering and Public Policy / Electrical and Computer Engineering – Ph.D., Stanford University; Carnegie Mellon, 1991–.

ALLEN ROBINSON, Raymond J. Lane Distinguished Professor; Head of Mechanical Engineering; Professor of Mechanical Engineering / Engineering and Public Policy – Ph.D., University of California, Berkeley; Carnegie Mellon, 1998–.

EDWARD S. RUBIN, Alumni Chair Professor of Environmental Engineering and Science; Professor of Engineering and Public Policy / Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 1969–.

DOUGLAS SICKER, Head of Engineering and Public Policy; Professor of Engineering and Public Policy / Computer Science – Ph.D., University of Pittsburgh; Carnegie Mellon, 2014–.

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MITCHELL J. SMALL, The H. John Heinz III Professor of Environmental Engineering; Professor of Civil and Environmental Engineering / Engineering and Public Policy; Associate Department Head for Graduate Affairs – Ph.D., University of Michigan; Carnegie Mellon, 1982–.

DEBORAH STINE, Professor of the Practice of Engineering and Public Policy – Ph.D., American University; Carnegie Mellon, 2012–.

ESWARAN SUBRAHMANYAN, Research Professor of Institute for Complex Systems / Engineering and Public Policy – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1984–.

SUBRA SURESH, President of Carnegie Mellon University; Professor of Materials Science and Engineering / Engineering and Public Policy / Biomedical Engineering / Public Policy and Management – Ph.D., MIT; Carnegie Mellon, 2013–.

JOEL A. TARR, Richard S. Caliguiri Professor of Urban and Environmental History and Policy; Professor of History / Engineering and Public Policy / The H. John Heinz III College – Ph.D., Northwestern University; Carnegie Mellon, 1967–.

JAY WHITACRE, Associate Professor of Materials Science and Engineering / Engineering and Public Policy – Ph.D., University of Michigan; Carnegie Mellon, 2007–.

HAIBO ZHAI, Assistant Research Professor of Engineering and Public Policy – Ph.D., North Carolina State University; Carnegie Mellon, 2008–.

Emeriti Faculty

TUNG AU, University Professor of Civil and Environmental Engineering / Engineering and Public Policy, Emeritus – Ph.D., University of Illinois; Carnegie Mellon, 1957–.

JAMES GOODBY, Distinguished Service Professor, Emeritus – A.B., Harvard ; Carnegie Mellon, 1989–.

CHRIS T. HENDRICKSON, Emeritus University Professor – PhD, MIT; Carnegie Mellon, 1978–.

FRANCIS MCMICHAEL, Walter J. Blenko, Senior Professor of Environmental Engineering; Professor of Civil and Environmental Engineering / Engineering and Public Policy, Emeritus – Ph.D., California Institute of Technology; Carnegie Mellon, 1967–.

BENOÎT MOREL, Associate Teaching Professor of Engineering and Public Policy / Physics, Emeritus – Ph.D., University of Geneva; Carnegie Mellon, 1987–.

INDIRA NAIR, Former Vice Provost for Education; Professor of Engineering and Public Policy, Emeritus – Ph.D., Northwestern University ; Carnegie Mellon, 1978–.

HENRY R. PIEHLER, Professor of Materials Science and Engineering / Engineering and Public Policy / Biomedical Engineering, Emeritus – Sc.D. , MIT; Carnegie Mellon, 1967–.

SAROSH TALUKDAR, Professor of Electrical and Computer Engineering / Engineering and Public Policy, Emeritus – Ph.D., Purdue University; Carnegie Mellon, 1974–.

ROBERT M. WHITE, University Professor of Electrical and Computer Engineering / Engineering and Public Policy, Emeritus – Ph.D., Stanford University; Carnegie Mellon, 1993–.

Department of Mechanical Engineering

Allen Robinson, Raymond J. Lane Distinguished Professor and Department Head
Scaife Hall 401
<http://www.cmu.edu/me>

General Overview

Mechanical engineers design, analyze, and manufacture new products and technologies. They address society's needs by combining mechanical engineering fundamentals with innovative ideas. We structure our curriculum by emphasizing engineering theory, hands-on experience and technical skills. By doing so, our students learn how to solve practical problems and analyze situations by converting concepts into reliable and cost-effective devices and processes.

Mechanical engineers work in a variety of sectors: small start-up companies, multi-national corporations, government agencies, national laboratories, consulting firms, and universities. Specializing in research, design, manufacturing, or management, they design and implement devices that affect our daily lives. For example:

- Jet Engines
- Automobiles
- Aircraft and Spacecraft
- Acceleration and Pressure Sensors
- Heating, Ventilating, and Air Conditioning Systems
- Power Generations Systems
- Biomedical and Biomechanical Devices (such as artificial hip implants)
- Mechanical and Electronic Systems (such as robots)

Through our curriculum, students receive a solid scientific foundation from the start. During their first year, students take courses in mathematics, physics, computer programming, and chemistry. In addition, students also take two introductory engineering courses which expose them to the different engineering departments. Our mechanical engineering introductory course is project-oriented; students learn about the various disciplines of mechanical engineering through lectures, laboratories, and hands-on projects.

In their sophomore and junior years, students take core engineering courses to develop strong engineering fundamentals. These course topics include:

- Solid and Fluid Mechanics
- Thermodynamics
- Heat Transfer
- Dynamics
- Systems and Controls
- Design Methods and Skills
- Experimentation and Numerical Methods

During their senior year, students complete a capstone course in engineering design. In this course, students work on teams to develop prototype hardware for new products. These projects expose students to the design process, from concept to product, and emphasize effective communication and presentations skills. Past design projects include:

- low-squeal disk brakes
- high efficiency engines
- neck gear to minimize spinal injury in sports
- stabilizer support arm for movie cameras

Additionally, students can utilize our flexible elective structure to pursue individual interests. We recognize the broad role mechanical engineers play in society—as leaders in business, government, and law. Therefore, we offer elective options that enable students to:

- begin taking elective courses during their junior year
- specialize in a particular area of mechanical engineering
- emphasize a technical area within another engineering or science department
- pursue interests in another Carnegie Mellon department (such as foreign language, design, music, or business) to earn a double major or minor

We offer advanced courses that students can choose as electives, depending on their interests. Electives include:

- energy conversion
- controls
- vibrations
- dynamics
- manufacturing
- robotics
- internal combustion engines
- mechatronics
- fluid and solid mechanics
- engineering design

As mentioned, students can also take technical and non-technical electives from other Carnegie Mellon departments. Students can use these courses to pursue a double major or minor, or develop an individual concentration with a faculty advisor.

Students can also tailor their undergraduate experiences through study abroad, research, or the Integrated Master's/Bachelor's Program. In today's global society, a study abroad experience is crucial and should serve as an integral part of an undergraduate engineering education, including a possible college Global Engineering minor. An academic experience abroad is encouraged and assistance provided for course choices, but students may also participate in research, complete an internship, or partake in an international service-learning engineering project abroad. Exceptional students are eligible to participate in departmental or college senior honors research under faculty supervision, which students find enriching. In the Integrated Master's/Bachelor's program, students take graduate courses during their senior year, accumulating credit toward their Master's degrees. Students can then complete all the requirements for the M.S. degree (course-work option) in the fall following their B.S. degree.

Students use the latest computer-based design and analysis methods for their courses and project work, including industry-standard design tools aided by computers. We provide an undergraduate computer lab where students can complete design work, structural analyses, thermal/fluid finite element analyses, and dynamic system simulations. Using computer tools, students can visualize a product's performance before they fabricate it.

We also provide students with a variety of resources including MIG welding, rapid prototyping, and a fully equipped student shop (includes lathes, drill presses, milling machines, band saws, and other hand and power tools). Our Thermal Fluids and Mechanical Systems laboratories contain state-of-the-art experimentation hardware and software.

Our faculty performs research sponsored by industry and government agencies. Faculty often use their research results as specific examples, case studies, and projects in undergraduate courses, allowing students to see firsthand the recent advances in mechanical engineering.

We also sponsor frequent seminars and invite nationally and internationally reputed speakers to give lectures. We encourage all students to attend these seminars to learn about broad perspectives on mechanical engineering.

You can find additional information about the Mechanical Engineering program on our website, <http://www.cmu.edu/me/>. Additionally, we describe our resources and policies in more detail in our Undergraduate Student Handbook, available online.

Educational Objectives

According to ABET (<http://www.abet.org/>) which evaluates applied science, computing, engineering and technology programs for accreditation, "program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation." In view of this definition, the Mechanical Engineering program at Carnegie Mellon has the two following program educational objectives:

- Graduates distinguish themselves as innovative problem solvers and leaders in multidisciplinary settings, making use of a high quality and rigorous technical education that is enriched by a flexible curriculum and interdisciplinary research opportunities.
- Graduates excel in diverse career paths in either the engineering profession or an alternative field, or succeed in graduate studies.

The undergraduate curriculum in the Department of Mechanical Engineering offers students significant opportunities to pursue directions of personal interest, including minors, double majors, participation in research projects, and study abroad. Design and teamwork experiences occur at regular

intervals in the curriculum, and graduates have significant hands-on experience through laboratories and projects. The faculty of the Department has endorsed the following set of skills, or outcomes that graduates of the program are expected to have:

- A. an ability to apply knowledge of mathematics, science, and engineering
- B. an ability to design and conduct experiments, as well as to analyze and interpret data
- C. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- D. an ability to function on multidisciplinary teams
- E. an ability to identify, formulate, and solve engineering problem
- F. an understanding of professional and ethical responsibility
- G. an ability to communicate effectively
- H. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- I. a recognition of the need for, and an ability to engage in lifelong learning
- J. a knowledge of contemporary issues
- K. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The Mechanical Engineering program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

Curriculum

The following template outlines the four-year B.S. program through the standard and recommended course sequence. To ensure that prerequisites are completed and to prevent scheduling conflicts, students should discuss any changes to this sequence with the department academic advisor.

Freshman Year

Fall	Units
21-120 Differential and Integral Calculus	10
24-101 Fundamentals of Mechanical Engineering	12
33-106 Physics I for Engineering Students	12
99-101 Computing @ Carnegie Mellon	3
76-101 Interpretation and Argument	9
	46

Spring	Units
21-122 Integration and Approximation	10
xx-xxx Second Introductory Engineering Course	12
xx-xxx Restricted Technical Elective 10-13	10
xx-xxx General Education Course	9
	41

Sophomore Year

Fall	Units
21-259 Calculus in Three Dimensions	9
24-221 Thermodynamics I	10
24-261 Statics	10
xx-xxx Restricted Technical Elective 10-13	13
xx-xxx General Education Course	9
24-200 Machine Shop Practice *Preferred sophomore year, required by senior year	1
39-210 Experiential Learning I	0
	52

Spring	Units
21-260 Differential Equations	9
24-231 Fluid Mechanics	10
24-262 Stress Analysis	12
xx-xxx Restricted Technical Elective 10-13	12

xx-xxx General Education Course	9
24-202 Introduction to Computer Aided Design *Required sophomore year	1
39-220 Experiential Learning II	0
	53

Junior Year

Fall	Units
24-302 Mechanical Engineering Seminar I- taken either fall or spring	2
24-322 Heat Transfer	10
24-370 Engineering Design I: Methods and Skills	12
24-351 Dynamics	10
36-220 Engineering Statistics and Quality Control	9
xx-xxx General Education Course	9
39-310 Experiential Learning III	0
	52

Spring	Units
24-321 Thermal-Fluids Experimentation	12
24-311 Numerical Methods	12
24-352 Dynamic Systems and Controls	12
xx-xxx General Education Course	9
	45

Senior Year

Fall	Units
24-441 Engineering Design II: Conceptualization and Realization- required either fall or spring; alternate with xx-xxx 9 unit elective	12
24-452 Mechanical Systems Experimentation	9
xx-xxx Elective	9
xx-xxx Elective	9
xx-xxx General Education Course	9
	48

Spring	Units
24-441 Engineering Design II: Conceptualization and Realization OR xx-xxx Elective	12
24-xxx Mechanical Engineering Technical Elective	9-12
xx-xxx Elective	9
xx-xxx Elective	9
xx-xxx General Education Course	9
	39

Notes on the Curriculum

- Students need a minimum of 382 units to complete the B.S. degree.
- During the first year, students complete 24-101 Fundamentals of Mechanical Engineering and another introductory engineering course. If students did not take 24-101 during their first year, they should take 24-101 during their fall semester of their sophomore year in place of the General Education Course. They can then replace that General Education Course in their junior or senior years.
- Students must pass the following three courses before they begin the core Mechanical Engineering courses in the fall of their sophomore year: 21-120 Differential and Integral Calculus (10 units) 21-122 Integration and Approximation (10 units) 33-106 Physics I for Engineering Students (12 units)*
*33-106 / 33-107 is the recommended sequence for engineering students, although 33-111 / 33-112 or 33-131 /33-132 would also meet the CIT Physics requirement.

Mechanical engineering undergraduates must satisfy a Science Laboratory requirement to graduate. Normally the Science Laboratory requirement is satisfied by passing 09-101 Introduction to Experimental Chemistry (3 units). Students can also satisfy the Science Laboratory requirement by passing one of the following courses:

03-124 Modern Biology Laboratory	9
33-100 Basic Experimental Physics	6
33-104 Experimental Physics	9

42-203	Biomedical Engineering Laboratory	9
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These courses may have prerequisites and tight enrollment limits that students should consider in their planning.

4. Students are required to complete 36-220 Engineering Statistics and Quality Control, which may be scheduled in any semester. The sequence of calculus courses (21-120 , 21-122 , 21-259) and 21-260 Differential Equations should be scheduled as indicated, due to Mechanical Engineering Core class prerequisites.

5. The communications requirement can be satisfied by completing at least one of the following options:

		Units
24-302	Mechanical Engineering Seminar I- either fall or spring	2
70-340	Business Communications	9
76-270	Writing for the Professions	9

6. Students must enroll in 24-452 Mechanical Systems Experimentation in the fall of their senior year.

7. 24-441 Engineering Design II: Conceptualization and Realization may be taken in either fall or spring of senior year.

Restricted Technical Electives

Students should have the following courses completed by the end of their sophomore year. These courses are listed as "Restricted Technical Electives" in the example course sequence. Students do have some flexibility in how they sequence these courses during their freshman and sophomore years:

33-107	Physics II for Engineering Students	12
09-101	Introduction to Experimental Chemistry	3
09-105	Introduction to Modern Chemistry I	10
15-110	Principles of Computing	10

Mechanical Engineering Technical Electives

We require students to take at least one elective labeled as "Mechanical Engineering Technical Elective" in the example course sequence. Students must take at least one non-core 24-xxx course (9-unit minimum) to fulfill the technical elective requirement. Options include:

Design and Manufacturing

24-341	Manufacturing Sciences	9
24-674	Design of Biomechatronic Systems for Humans	12
24-681	Computer-Aided Design	12
24-682	Computer-Aided Engineering	12
24-683	Design for Manufacture and the Environment	12
24-688	Introduction to CAD and CAE Tools	12

Mechanical Systems

24-355	Kinematics and Dynamics of Mechanisms	9
24-361	Intermediate Stress Analysis	10
24-451	Feedback Control Systems	12
24-655	Cellular Biomechanics	9
24-657	Molecular Biomechanics	9

Thermal-Fluid Systems

24-332	Potential Flow Aerodynamics	9
24-421	Internal Combustion Engines	12
24-424	Energy and the Environment	9
24-425	Combustion and Air Pollution Control	9
24-615	Microfluidics	12
24-616	Tribology-Friction, Lubrication and Wear	12
24-623	Molecular Simulation of Materials	12
24-642	Fuel Cell Systems	12

We regularly offer these courses and/or new options according to our teaching schedule. However we cannot guarantee to offer a particular course in a given semester.

Students can also take certain mechanical engineering graduate courses to fulfill the technical elective requirement. However, students must have the appropriate prerequisites and the instructor must approve taking the course. Students can find a list of graduate courses we offer on our website.

Students cannot use the research or project courses to fulfill the technical elective requirement. However, they can use these courses to fill the remaining five elective slots. Courses that do not fulfill the technical elective requirements are:

24-391/ 24-392 Mechanical Engineering Project
24-491/ 24-492 Department Research Honors
39-xxx CIT series courses

Electives

Students must complete five elective courses, as indicated in the example course sequence. Students can take either technical or non-technical courses to fill these five slots from either the mechanical engineering department, College of Engineering, or any other Carnegie Mellon department. However, students may only use one elective slot for a physical education course or for ROTC. We offer these electives so students can pursue individual interests or obtain a minor or double major.

Constructing a Program of Study

In order to properly plan their course sequence, students should select their six elective courses with the department academic advisor. If students are pursuing minors, double majors, or double degrees, they should choose electives that meet requirements of these programs. We provide more information on selecting courses and electives in the Undergraduate Student Handbook. We offer the following options to students for tailoring our program to fit their needs and interests.

Specialization Within Mechanical Engineering

Students can specialize in a specific area by taking additional mechanical engineering electives beyond the one required technical elective. Students can choose courses from the Mechanical Engineering Technical Electives list or take approved mechanical engineering graduate courses.

Research and Independent Study Projects

Students can work on a design or research project if supervised and coordinated by a faculty advisor. Interested students should contact faculty members to identify potential projects of mutual interest. Projects generally involve lab, analytical, field, design or computer work.

Students complete projects and research by taking either or both of the following courses for their electives. As previously mentioned, students cannot use these courses to fulfill the technical elective requirement.

24-391/392	Mechanical Engineering Project	Var.
24-491/492	Department Research Honors	Var.

*Students enrolled in 24-391/392 do not have an additional QPA (quality point average) requirement for this course.

Qualified students enrolled in 24-491/492 are recognized at commencement. To graduate with research honors, students must have a QPA of 3.2 or higher, complete 18 units of 24-491/492 with at least at least a "B" grade, and submit an approved thesis to their faculty research advisor.

Students who complete all requirements for CIT Honors Research will also graduate with research honors. These students must complete 18 units of (39-500) CIT Honors Research under the supervision of a mechanical engineering faculty member.

Developing a Concentration of Interdisciplinary Studies

Students can also take courses outside of mechanical engineering to fill elective slots. Usually students select courses around a common theme; although courses span several departments, students choose courses to form a specific concentration. Students can either construct an informal program of study based on their interests or they can pursue a minor or double major using these courses.

Pursuing a Minor or Double Major

The College of Engineering offers designated minors for students wishing to specialize in an engineering area. Students can find a list of minors on the CIT website (www.cit.cmu.edu). Students can generally complete a designated minor without increasing the number of units required for graduation, but they should plan early in order to complete a minor on time.

Students can also complete a double major within the College of Engineering. Students can earn double majors in Mechanical Engineering and Engineering and Public Policy, or Mechanical Engineering and Biomedical Engineering.

Additionally, students can pursue minors or double majors with other Carnegie Mellon departments. Interested students should contact the main

department of the minor/double major they seek to learn the requirements for that program.

Advising

The department academic advisors are assigned initially to all new students and will continue to assist with any curriculum questions and registration issues until they graduate.

The department academic advisors will:

- Verify progress toward degree requirements
- Discuss course alternatives for CIT requirements and electives
- Register research credit
- Assist with pre-requisite waivers
- Offer basic information regarding double major/minors, study abroad procedures, etc
- Explain summer transfer credit policies

Faculty mentors will:

- Explain technical content of coursework
- Suggest appropriate concentrations that match students' career objectives
- Discuss research opportunities
- Offer graduate school and employment advice
- Offer general advice and mentoring

Students should attend the fall sophomore lunch to meet professors, utilize introductions during sophomore core classes and check the website for additional faculty information. Faculty appointments as needed, may also be arranged through the academic advising office. The academic advisor will assign a faculty mentor to students that have not indicated a selection at the end of the sophomore year.

As a regular part of monitoring progress toward completion of the degree, students should compare their transcripts with the department's degree requirements. Academic Audit - the HUB website- www.cmu.edu/hub.

Integrated Master's/Bachelor's Degree (IMB)

An integrated program is available to Carnegie Mellon engineering undergraduate students who also wish to complete a master's degree in mechanical engineering (MSC option).

As reflective of the CIT Integrated Master's/Bachelor's Degree Program policy, effective Fall 2012, students may complete their master's degree with only one additional full-time semester after the bachelor's degree. Student's participating in IMB will be changed to graduate status during the 9th (and subsequent) semesters.

Students must complete at least 24 units of graduate coursework by the end of the Senior year. A QPA of 3.0 or better must be attained in those courses, and they cannot be used to satisfy the requirements of the bachelor's degree. Students must also have a cumulative undergraduate QPA of a 3.0 or higher. During the summer immediately after the Senior year, students could complete up to 12 units of Graduate Supervised Reading or Graduate Master of Science Project. During the following Fall semester, students then complete all remaining coursework (a maximum of 60 units per semester). A total of 96 units are required for completion of the MSC option.

Interested students are **required** to complete the Integrated Master's/Bachelor's Degree Program Form.

Quality Point Average Requirements

To be eligible to graduate, undergraduate students must complete all course requirements for their program with a cumulative Quality Point Average of at least 2.00 for all courses taken. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. The Mechanical Engineering Department requires that students attain a quality point average of 2.00 or higher for all required Mechanical Engineering core courses.

Pursuant to university rules, students can repeat a course in which a grade below C was attained in order to achieve the QPA requirement. When a course is repeated, all grades will be recorded on the official academic transcript and will be calculated in the student's QPA. The highest grade so

obtained will be used to calculate the quality point average for all required Mechanical Engineering courses.

Full-Time Faculty

SHELLEY ANNA, Professor of Mechanical Engineering – Ph.D, Harvard University; Carnegie Mellon, 2003–.

JACK LEE BEUTH, Professor of Mechanical Engineering – Ph.D., Harvard University; Carnegie Mellon, 1992–.

JONATHAN CAGAN, George Tallman and Florence Barrett Ladd Professor of Mechanical Engineering – Ph.D, University of California, Berkeley; Carnegie Mellon, 1990–.

STEVEN COLLINS, Associate Professor of Mechanical Engineering – Ph.D, University of Michigan; Carnegie Mellon, 2010–.

MAARTEN P. DE BOER, Professor of Mechanical Engineering – Ph.D, University of Minnesota; Carnegie Mellon, 2007–.

NOÉ VARGAS HERNÁNDEZ, Associate Professor of Mechanical Engineering – Ph.D, Arizona State University; Carnegie Mellon, 2014–.

C. FRED HIGGS III, Professor of Mechanical Engineering – Ph.D., Rensselaer Polytechnic Institute; Carnegie Mellon, 2003–.

B. REEJA JAYAN, Assistant Professor of Mechanical Engineering – Ph.D, University of Texas-Austin; Carnegie Mellon, 2015–.

LEVENT BURAK KARA, Associate Professor of Mechanical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–.

PHILIP R. LEDUC, William J. Brown Professor of Mechanical Engineering – Ph.D., The Johns Hopkins University; Carnegie Mellon, 2002–.

SHAWN LITSTER, Associate Professor of Mechanical Engineering – Ph.D, Stanford University; Carnegie Mellon, 2008–.

CARMEL MAJIDI, Assistant Professor of Mechanical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 2011–.

JONATHAN A. MALEN, Associate Professor of Mechanical Engineering – Ph.D, University of California, Berkeley; Carnegie Mellon, 2009–.

ALAN J.H. MCGAUGHEY, Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2005–.

JEREMY J. MICHALEK, Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2005–.

O. BURAK OZDOGANLAR, Ver Planck Professor of Mechanical Engineering – Ph.D, University of Michigan; Carnegie Mellon, 2004–.

ALBERT PRESTO, Assistant Research Professor of Mechanical Engineering – Ph.D, Carnegie Mellon University; Carnegie Mellon, 2012–.

YOED RABIN, Professor of Mechanical Engineering – D.Sc., Technion-Israel Institute of Technology; Carnegie Mellon, 2000–.

ALLEN L. ROBINSON, Raymond J. Lane Distinguished Professor & Department Head – Ph.D., University of California, Berkeley; Carnegie Mellon, 1998–.

EDWARD STEPHEN RUBIN, Professor of Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 1969–.

SHENG SHEN, Assistant Professor of Mechanical Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2011–.

KENJI SHIMADA, Theodore Ahrens Professor of Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1996–.

SATBIR SINGH, Assistant Teaching Professor of Mechanical Engineering – Ph.D, University of Wisconsin-Madison; Carnegie Mellon, 2012–.

METIN SITTI, Professor of Mechanical Engineering – Ph.D., University of Tokyo; Carnegie Mellon, 2002–.

KOUSHIL SREENATH, Assistant Professor of Mechanical Engineering – Ph.D., University of Michigan at Ann Arbor; Carnegie Mellon, 2013–.

PAUL SETH STEIF, Professor of Mechanical Engineering – Ph.D., Harvard University; Carnegie Mellon, 1983–.

RYAN SULLIVAN, Assistant Professor of Mechanical Engineering – Ph.D., University of California at San Diego; Carnegie Mellon, 2012–.

VENKAT VISWANATHAN, Assistant Professor of Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 2013–.

SHI-CHUNE YAO, Professor of Mechanical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 1977–.

YONGJIE ZHANG, Associate Professor of Mechanical Engineering - Ph.D., University of Texas at Austin; Carnegie Mellon, 2007-.

Emeriti

ADNAN AKAY, Lord Emeritus Professor of Mechanical Engineering - PhD, North Carolina State University; Carnegie Mellon, 1992-.

NORMAN CHIGIER, Emeritus Professor of Mechanical Engineering - Sc.D., University of Cambridge; Carnegie Mellon, 1981-.

JERRY HOWARD GRIFFIN, William J. Brown Emeritus Professor of Mechanical Engineering - Ph.D., California Institute of Technology; Carnegie Mellon, 1981-.

WILFRED THOMAS ROULEAU, Emeritus Professor of Mechanical Engineering - Ph.D., Carnegie Institute of Technology; Carnegie Mellon, 1954-.

Department of Materials Science and Engineering

Gregory S. Rohrer, Head Office: Wean Hall 3327
<http://materials.cmu.edu>

Materials Science & Engineering (MSE) is an engineering discipline that applies the tools of basic and applied sciences and engineering to the manufacture and application of materials and devices. The four broad classes of Materials to which this paradigm is applied are metals, polymers, ceramics, and composites. Essentially every technology (historical, modern, and future) depends on materials development and innovation.

The overarching paradigm of MSE is to determine and to exploit the connection between processing, structure, and properties of materials to engineer materials that fit the performance criteria for specific applications, which are useful for the technological needs of our society. In addition to this product specific knowledge, MSE is concerned with the implications of materials production and their sustainable use on the environment and energy resources.

Graduates of the MSE department are pursuing careers in an expanding spectrum of companies, national laboratories, and universities. Their activities cover a wide range of materials related endeavors that include microelectronics, energy production and storage, biomedical applications, aerospace, information technology, nanotechnology, manufacturing and materials production. Many of our undergraduate alumni choose to attend graduate school; they are accepted into the top Materials graduate schools in the country.

The standard curriculum of the department provides fundamental training for all materials science and engineering areas (http://materials.cmu.edu/ugrad/std_fresh.html). The core courses provide understanding and training on tools for working with the (atomic) structure of materials that governs their properties, the thermodynamic relationships that govern the stability of materials, and the rates at which changes take place in materials. Students complete their learning with a capstone design experience in the final year, which integrates their materials knowledge and training with engineering team skill development. To supplement the core course program, students may also participate in the current research programs of the faculty and conduct undergraduate research projects as part of their program of study.

While the core program is focused on the understanding of the internal or surface structure of materials in order to predict and engineer their properties, there is also an elective program that allows students to focus within a chosen material class, whether it is ceramics, semiconductors, metals, composites, magnetic or optical materials, bio-materials or polymers. The option of concentration in the one or more of the areas of application such as electronic materials*, engineering design*, biomedical engineering*, environmental engineering*, manufacturing engineering*, mechanical behavior of materials*, biomedical and health engineering**, and engineering and public policy**, is also available. (*= Designated Minor, **= Double Major). Our curriculum is designed to provide a strong foundation in fundamental knowledge and skills that provide an excellent base for our graduates planning to continue on to graduate studies. For our graduates who seek employment in industry, the program provides the foundation on which a graduate can build his/her domain specific knowledge. For students that develop or seek opportunities in other disciplines after graduation, the MSE curriculum provides a modern liberal education combined with the engineering rigors, i.e. one that inculcates a thoughtful, problem-solving approach to professional life. It is thus the goal of our education to provide a global and modern education in Materials Science and Engineering to support our graduates during their careers in materials industries or as a foundation for further studies in any of the leading global institutions of graduate education.

Accreditation

The MSE Undergraduate Program is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

Educational Objectives

The faculty of the Department of Materials Science and Engineering, in consultation with students, alumni and other interested parties, has decided that the overarching objective of the MSE curriculum is to provide an education that enables our graduates to be productive and fulfilled professionals throughout their careers.

Specifically, our program will produce graduates who:

1. are successful in a top graduate school and/or in materials science & engineering positions;
2. excel in professionalism and leadership in modern interdisciplinary materials engineering practice, while accounting for the impact of their profession on an evolving society;
3. creatively advance our collective understanding of the principles of materials science and engineering and/or innovate the design of technological systems;
4. contribute effectively as an individual, team member, and/or a leader to achieve personal, group and institutional goals.

Based on these objectives, our program is focused to allow our students to be successful regardless of their future career choice.

Student Outcomes

The Materials Science and Engineering Program has the following student outcomes to prepare graduates to attain the program educational objectives:

MSE Outcome A:

An ability to apply a knowledge of mathematics, science and engineering

MSE Outcome B:

An ability to design and conduct experiments, as well as to analyze and interpret data

MSE Outcome C:

An ability to design a system component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

MSE Outcome D:

An ability to function on multidisciplinary teams

MSE Outcome E:

An ability to identify, formulate, and solve engineering problems

MSE Outcome F:

An understanding of professional and ethical responsibility

MSE Outcome G:

An ability to communicate effectively

MSE Outcome H:

The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

MSE Outcome I:

A recognition of the need for, and ability to engage in life-long learning

MSE Outcome J:

A knowledge of contemporary issues

MSE Outcome K:

An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Standard Program

Freshman Year

Fall		Units
21-120	Differential and Integral Calculus	10
27-100	Engineering the Materials of the Future *	12
33-106	Physics I for Engineering Students #	12
99-101	Computing @ Carnegie Mellon	3
xx-xxx	General Education Course	9
		46

Spring		Units
21-122	Integration and Approximation	10
33-107	Physics II for Engineering Students **	12
xx-xxx	Introductory Engineering Elective	12
09-101	Introduction to Experimental Chemistry	3
76-101	Interpretation and Argument	9
		46

Sophomore Year

Fall		Units
27-201	Structure of Materials	9
27-210	Materials Engineering Essentials	6
27-215	Thermodynamics of Materials	12
21-259	Calculus in Three Dimensions	9
09-105	Introduction to Modern Chemistry I **	10
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
39-210	Experiential Learning I	0
		56

Spring		Units
27-202	Defects in Materials	9
27-205	Introduction to Materials Characterization	3
27-216	Transport in Materials	9
27-217	Phase Relations and Diagrams	12
21-260	Differential Equations	9
39-220	Experiential Learning II	0
xx-xxx	General Education Course	9
		51

Junior Year

Fall		Units
27-301	Microstructure and Properties I	9
27-xxx	MSE Restricted Elective [1]	9
xx-xxx	Free Elective [1]	9
33-225	Quantum Physics and Structure of Matter or	9
or 09-217	Organic Chemistry I	
or 03-121	Modern Biology	
xx-xxx	General Education Course	9
39-310	Experiential Learning III	0
		45

Spring		Units
27-367	Selection and Performance of Materials	6
xx-xxx	General Education Course	9
27-xxx	MSE Restricted Elective [2]	9
27-xxx	MSE Restricted Elective [3]	9
xx-xxx	Free Elective [2]	9
36-220	Engineering Statistics and Quality Control	9
		51

Senior Year

Fall		Units
27-401	MSE Capstone Course I	12
27-xxx	MSE Restricted Elective [4]	9
xx-xxx	Free Elective [3]	9
xx-xxx	H&SS Elective [1]	9
xx-xxx	General Education Course	9
		48

Spring		Units
27-xxx	MSE Approved Technical Elective	9
xx-xxx	Free Elective [4]	9
xx-xxx	Free Elective [5]	9
xx-xxx	H&SS Elective [2]	9
		36

379 Minimum number of units required for degree:

* The Materials in Engineering course 27-100 may also be taken in the spring semester, and must be taken before the end of the sophomore year (the H&SS Elective in the Sophomore Spring may be moved to later in the program to accommodate the 27-100 course).

** These courses must be taken before the end of the sophomore year, but need not be taken in the same order or semester as listed above.

The recommended sequence is 33-106 / 33-107 for Engineering students. However, 33-111 / 33-112 or 33-131 / 33-132 will also meet the CIT Physics requirement.

Industrial Intern Program

An industrial internship option (IIO - cooperative educational program) within the department offers an MSE student an opportunity to obtain valuable experience and insight from alternating periods in industry and on campus (beginning the spring after the sophomore year). The combination of learning while participating in an industrial environment with academic course work creates strongly motivated students and a personalized learning situation. Graduation with a B.S. degree occurs four and one-third calendar years after entering the university. Exceptionally able students may be admitted to a program leading to both the B.S. and M.S. degrees in five years. Students in the IIO program should consult with their faculty advisors before electing to participate in any of the designated minor programs.

Following the standard or industrial internship programs the graduate of the Department of Materials Science and Engineering is well prepared for leadership in our highly technological society which continues to demand more and more from the materials used in engineered systems. Many of our graduates elect to continue their education to the Master's and Doctoral Level in order to satisfy their need for advanced education in the discipline.

Notes on the Curriculum

Quality Point Average

In addition to the College requirement of a minimum cumulative quality point average of 2.00 for all courses taken beyond the freshman year, the Department requires a quality point average of 2.00 or higher in courses taken in the MSE department. Students may repeat a course to achieve the QPA requirement. Only the higher grade will be used for this departmental calculation.

MSE Restricted Electives

The MSE Restricted Electives are listed below. Each student in the Standard or Industrial Internship program must take at least 45 units from this list. In double major programs at least 36 units are required. The total number of units may be reached through any combination of the courses below.

		Units
27-323	Powder Processing of Materials	9
27-324	Introduction to Polymer Science and Engineering	9
27-402	MSE Capstone Course II	12
27-410	Computational Techniques in Engineering	12
27-411	Engineering Biomaterials	9
27-421	Processing Design	6
27-432	Electronic and Thermal Properties of Metals, Semiconductors and Related Devices	9

27-433	Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices	9
27-445	Structure, Properties and Performance Relationships in Magnetic Materials	9
27-454	Supervised Reading	Var.
27-520	Tissue Engineering	12
27-533	Principles of Growth and Processing of Semiconductors	6
27-542	Processing and Properties of Thin Films	9
27-551	Properties of Ceramics and Glasses	9
27-555	Materials Project I	Var.
27-556	Materials Project II	Var.
27-561	Special Topics: Kinetics of Metallurgical Reactions and Processes	6
27-565	Nanostructured Materials	9
27-566	Special Topics in MSE: Using Matls Informatics to Assess Societal Impact of Matls	9
27-570	Molecular and Micro-scale Polymeric Biomaterials in Medicine	9
27-582	Phase Transformations in Solids	9
27-591	Mechanical Behavior of Materials	9
27-592	Solidification Processing	9
06-466	Experimental Polymer Science	9
06-609	Physical Chemistry of Macromolecules	9
06-619	Semiconductor Processing Technology	9
09-509	Physical Chemistry of Macromolecules	9
12-201	Geology	9
12-411	Project Management for Construction	9
12-631	Structural Design	12
18-310	Fundamentals of Semiconductor Devices	12
24-262	Stress Analysis	12
24-341	Manufacturing Sciences	9
24-361	Intermediate Stress Analysis	10
33-341	Thermal Physics I	10
33-448	Introduction to Solid State Physics	9
42-411	Engineering Biomaterials	9
42-699	Special Topics- Tissue Engineering	12

* Any materials based research project within CIT under an advisor of Courtesy Standing in MSE, at advisors discretion.

MSE graduate courses may also be counted as restrictive electives subject to approval by Undergraduate advisors.

Integrated B.S./M.S. Program

Undergraduates who excel academically have the unique opportunity to receive simultaneously or sequentially both B.S. and M.S. degrees from the department. The primary purpose of the Integrated Master and Bachelor (IMB) Degree Program is to provide students with superior breadth and depth in technical material, which will better prepare them for careers in industry. Students interested in pursuing the IMB Degrees are encouraged to begin taking some of the required graduate courses before their last year. The MSE department offers two M.S. degrees: one in Materials Science and Engineering (MSE), a coursework degree, and one in Materials Science (MS), a coursework + research degree. The IMB Degree Program to obtain an M.S. in MSE (MS) degree normally requires two (three to four) additional full academic semesters of coursework (coursework + research) beyond the B.S. Degree Requirements (normally eight academic semesters). Experience has shown that students complete the IMB program in eight to ten full academic semesters after enrolling at CMU.

Degree Requirements

IMB students can be enrolled in either the M.S. in MSE (coursework) or the M.S. in MS (coursework + research) degree programs, depending on their preference.

Students must meet the requirements of either the M.S. in MSE or the M.S. in MS degree programs, as well as any specially stated rules below.

Eligibility

The IMB Program is available to all undergraduates who maintain a cumulative QPA of 3.0 or better, including the freshman year and the years in which they are enrolled in the IMB. Exceptions can be made by the Department on the basis of other factors, including extenuating (e.g., medical) circumstances, improvement in grades, strong recommendation letters, etc.

Students become eligible to apply to the program during the spring semester of their junior year (5th semester), or the semester in which they accumulate 280 or more units, whichever is earlier.

Enrollment

Students interested in the IMB program are not required to follow the formal application process for acceptance into the MSE graduate program. There is no requirement to provide a formal application, application fee, GRE scores, recommendation letters, official transcripts, or a statement of purpose. Interested students are encouraged request acceptance into the program by contacting the Department Head of MSE by email prior to the middle of the semester in which they become eligible.

Requirements to Enroll as a Graduate Student

If a student takes more than 8 semesters to complete both the B.S. and M.S. in MSE (coursework), then he or she must be a graduate student for at least one full-time 15-week academic semester (Fall or Spring) before graduating, whether or not they have already completed their B.S. degree.

If a student takes more than 8 semesters to complete both the B.S. and M.S. in MS (coursework + research), then he or she must be a graduate student for at least two full-time 15-week academic semesters (Fall or Spring) before graduating, whether or not they have already completed their B.S. degree.

Tuition Assistance

When a student is a full-time graduate student through the IMB program, the department is able to provide some tuition assistance through optional Teaching Assistantships.

Additional Information

Once the student has been accepted, the student should meet with his or her IMB academic advisor(s) to determine a course schedule.

The student must indicate departmental program coordinator at which point they intend, if necessary, to register as a graduate student.

Once a student in the IMB program has completed all of the requirements for the B.S. degree, he or she should become a graduate student.

To determine the most appropriate time for an undergraduate student to become a graduate student, he or she should consult with Enrollment Services to understand how becoming a graduate student will affect financial aid.

Faculty

CHRIS BETTINGER, Associate Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2010–.

MICHAEL BOCKSTALLER, Professor – Ph.D., Max-Planck Institute for Polymer Research; Carnegie Mellon, 2005–.

ROBERT F. DAVIS, Professor – Ph.D., University of California, Berkeley; Carnegie Mellon, 2004–.

MARC DE GRAEF, Professor – Ph.D., Catholic University Leuven (Belgium); Carnegie Mellon, 1993–.

ADAM FEINBERG, Associate Professor – Ph.D., University of Florida; Carnegie Mellon, 2010–.

RICHARD J. FRUEHAN, Professor – Ph.D., University of Pennsylvania; Carnegie Mellon, 1981–.

WARREN M. GARRISON, Professor – Ph.D., University of California at Berkeley; Carnegie Mellon, 1984–.

ROBERT HEARD, Teaching Professor – Ph.D., University of Toronto; Carnegie Mellon, 2003–.

ELIZABETH A. HOLM, Professor – Ph.D., University of Michigan; Carnegie Mellon, 2012–.

MOHAMMAD F. ISLAM, Associate Research Professor of Materials Science and Engineering – Ph.D., Lehigh University; Carnegie Mellon, 2005–.

DAVID E. LAUGHLIN, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1974–.

MICHAEL E. MCHENRY, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1989–.

YOOSUF PICARD, Associate Research Professor – Ph.D., University of Michigan; Carnegie Mellon, 2009–.

P. CHRIS PISTORIUS, Professor – Ph.D., University of Cambridge; Carnegie Mellon, 2008–.

LISA M. PORTER, Professor – Ph.D., North Carolina State; Carnegie Mellon, 1997-.

GREGORY S. ROHRER, Professor and Head – Ph.D., University of Pennsylvania; Carnegie Mellon, 1990-.

ANTHONY D. ROLLETT, Professor – Ph.D., Drexel University; Carnegie Mellon, 1995-.

PAUL A. SALVADOR, Professor – Ph.D., Northwestern University; Carnegie Mellon, 1999-.

MAREK SKOWRONSKI, Professor – Ph.D., Warsaw University; Carnegie Mellon, 1988-.

VINCENT SOKALSKI, Assistant Research Professor – Ph.D., Carnegie Mellon; Carnegie Mellon, 2013-.

SUBRA SURESH, Professor and President of the University – Sc.D., Massachusetts Institute of Technology; Carnegie Mellon, 2013-.

ELIAS TOWE, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2001-.

BRYAN A. WEBLER, Assistant Professor – Ph.D., Carnegie Mellon; Carnegie Mellon, 2013-.

JAY WHITACRE, Professor – Ph.D., University of Michigan; Carnegie Mellon, 2007-.

Emeriti Faculty

THADDEUS B. MASSALSKI, Professor Emeritus of Physics, Materials Science and Engineering – Ph.D., D.Sc., University of Birmingham, England D.Sc. (h), University of Warsaw, Poland;; Carnegie Mellon, 1959-.

HENRY R. PIEHLER, Professor of Materials Science and Engineering, and Public Policy – D.Sc., Massachusetts Institute of Technology; Carnegie Mellon, 1967-.

PAUL WYNBLATT, Professor Emeritus of Materials Science and Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 1981-.

Affiliated Faculty

AMIT ACHARYA, Professor, Civil and Environmental Engineering – Ph.D., University of Illinois, Urbana-Champaign; Carnegie Mellon, 2000-.

JAMES BAIN, Professor, Electrical and Computer Engineering – Ph.D., Stanford University; Carnegie Mellon, 1993-.

JACK BEUTH, Professor, Mechanical Engineering – Ph.D., Harvard University; Carnegie Mellon, 1992-.

MAARTEN DE BOER, Associate Professor of Mechanical Engineering – Ph.D., University of Minnesota; Carnegie Mellon, 2007-.

PHIL CAMPBELL, Research Professor, Institute for Complex Engineered Systems – Ph.D., The Pennsylvania State University; Carnegie Mellon, 2000-.

ITZHAQ COHEN-KARNI, Assistant Professor of Biomedical Engineering – Ph.D., Harvard University; .

KRIS NOEL DAHL, Associate Professor of Chemical Engineering and BioMedical Engineering and Materials Science and Engineering – Ph.D., University of Pennsylvania; Carnegie Mellon, 2006-.

KAUSHIK DAYAL, Associate Professor of Civil and Environmental Engineering – Ph.D., California Institute of Technology; Carnegie Mellon, 2008-.

RANDALL FEENSTRA, Professor, Physics – Ph.D., California Institute of Technology Carnegie Mellon; Carnegie Mellon, 1995-.

STEPHEN GAROFF, Professor, Physics – Ph.D., Harvard University; Carnegie Mellon, 1988-.

ANDREW GELLMAN, Lord Professor, Chemical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 1992-.

JOHN KITCHIN, Associate Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 2006-.

DAVID KINDERLEHRER, Professor, Mathematical Sciences – Ph.D., University of California, Berkeley; Carnegie Mellon, 1990-.

TOMEK KOWALWESKI, Professor of Chemistry – Ph.D., Polish Academy of Sciences; Carnegie Mellon, 2000-.

JOATHAN MALEN, – Ph.D., University of California, Berkeley; Carnegie Mellon, 2009-.

KRZYSZTOF MATYJASZEWSKI, J.C. Warner Professor of Natural Sciences, Department of Chemistry and Materials Science and Engineering – Ph.D., Polytechnical University of Łódź, Poland; Carnegie Mellon, 1985-.

ALAN MCGAUGHEY, Associate Professor – Ph.D., University of Michigan; Carnegie Mellon, 2005-.

O. BURAK OZDOGANLAR, Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2004-.

ROBERT SEKERKA, University Professor, Physics, Mathematics and Materials Science – Ph.D., Harvard; Carnegie Mellon, 1969-.

ROBERT SUTER, Professor, Physics – Ph.D., Clark University; Carnegie Mellon, 1981-.

LYNN WALKER, Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 1997-.

NEWELL R. WASHBURN, Associate Professor of Chemistry, Biomedical Engineering and Materials Science and Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 2004-.

LEE WEISS, Research Professor, ICES – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1983-.

MICHAEL WIDOM, Professor of Physics – Ph.D., University of Chicago; Carnegie Mellon, 1985-.

JIAN-GANG ZHU, Professor, Electrical and Computer Engineering – Ph.D., University of California at San Diego,; Carnegie Mellon, 1997-.

College of Fine Arts

Dan J. Martin, Dean (CFA 100)
 Eric Anderson, Associate Dean for Faculty Development and Governance (MM 110)
 Franco Sciannameo, Associate Dean for Interdisciplinary Initiatives (PCA G302)
<http://www.cfa.cmu.edu>

Overview

The College of Fine Arts at Carnegie Mellon University was founded in 1905 as the first comprehensive arts learning institution in the United States. For 110 years it has educated outstanding artists, architects, designers, theater artists and musicians who have made important contributions to culture in the United States and the world. The alumni of the College of Fine Arts have shaped the worlds of television, stage, film, and electronic media; are collected in numerous international museums; have composed for and are performing in and conducting major symphony orchestras, choruses and opera companies throughout the world; have built notable buildings, pioneered innovative sustainable design strategies and created interactive software systems; created significant innovations in graphic and industrial design; and are professors and deans in major arts institutions.

The College of Fine Arts concentrates on the education of professionals in the arts in the broader context of Carnegie Mellon University. Beyond their education in their chosen field, through required and elective course work, students are involved with other disciplines within the College of Fine Arts and within the other colleges of Carnegie Mellon University. Further, the College's location in the Oakland District of Pittsburgh with its broad cultural resources (The Carnegie Museum of Art, the Carnegie Museum of Natural History, The Carnegie Library, the University of Pittsburgh, The Hillman Library, the Frick Fine Arts Building, and Phipps Conservatory and Botanical Gardens) places the College of Fine Arts at the center of a premier cultural environment.

The College of Fine Arts has a 9:1 student faculty ratio which provides a rigorous learning environment. It is a highly spirited federation of schools (Architecture, Art, Design, Drama and Music) made up of students and faculty who have an intense need to create and excel. Interacting among the schools, the University and the wider community are research centers such as the Frank-Ratchye Studio for Creative Inquiry, the Center for Building Performance and Diagnostics, Remaking Cities Institute, Center for Iranian Music, and the Center for Arts in Society. The intellectual and artistic life of the College is interwoven with a dense calendar of theater performances, concerts, exhibitions, film and media presentations and lectures by visiting artists, practitioners and scholars.

The College of Fine Arts offers a wide range of professionally oriented majors and minors in each of its schools. In addition, the College offers the Bachelor of Humanities and Arts (BHA), jointly with the Dietrich College of Humanities and Social Sciences, the Bachelor of Science and Arts (BSA), jointly with the Mellon College of Science, the Bachelor of Computer Science and Arts (BCSA), jointly with the School of Computer Science, and the Master of Arts Management (MAM) and Master of Entertainment Industry Management (MEIM), jointly with the Heinz College of Public Policy and Management. These are presented only briefly below, but a complete listing of the graduation requirements for these programs may be found in the school descriptions later in this section and elsewhere in this volume.

Architecture Office: CFA 201

The School of Architecture offers a five-year NAAB accredited Bachelor of Architecture undergraduate degree for students who seek professional careers in architectural practice. Beyond standard preparation in architectural design, history and representation, its curriculum stresses the centrality of aesthetics, scientific knowledge and tectonic resolution in the education of future practicing professionals. A core of university course work in mathematics, physical sciences, social sciences, writing and history is prerequisite to sequences in design, building and environmental technology, and architectural history. The school offers M.S. degrees in Architecture; Architecture, Engineering & Construction Management; Building Performance and Diagnostics; Computational Design; and Sustainable Design. In addition, the School offers a Masters of Urban Design and a Masters of Tangible Interaction Design. The School of Architecture has a well-known architectural Ph.D. program that provides qualified students with the opportunity to continue their studies in the areas of specialization for which the School is recognized.

Art Office: CFA 300

The primary mission of the School of Art is to develop in the individual student the skills, knowledge, and commitment required to work as an artist in society. The four-year undergraduate program leads to a Bachelor of Fine Arts degree in Art. Concentrations within the art major are offered in four areas: 1) Painting, Drawing, Print Media and Photography; 2) Electronic and Time-Based Work; 3) Sculpture, Installation, and Site Work; and 4) Contextual Practice. A Master of Fine Arts degree in Art is also offered.

Design Office: MM 110

The School of Design combines its professional program with a sound education in the liberal arts, leading to careers in many fields of design. It offers the following degrees: Bachelor of Design with concentrations in Communications, Products, and Environments; M.Design in Design for Interactions; M.P.S. in Design for Interactions; M.A. in Design; M. of Integrated Innovation for Productions & Services (a joint degree with the Department of Mechanical Engineering and the Tepper School of Business); Ph.D. in Design; Doctor in Design.

Drama Office: PCA 220

The School of Drama offers a highly focused, world-class theatre education with thorough preparation for sustained careers and innovation in today's widely-varied entertainment industries. The undergraduate programs lead to BFA degrees in Drama, with focuses in Acting, Music Theatre, Directing, Dramaturgy, Design, Production Technology and Management; MFA programs are offered in Scene, Costume, Sound, and Lighting Design; Directing; Dramatic Writing; and Production Technology and Management.

Music Office: CFA 105

The School of Music has as its goal the preparation of musicians for careers in performance, composition, conducting, music education and music technology. The programs provide the opportunity to study with world-class artists utilizing the best aspects of conservatory training in the context of a major research university, combining the educational with the intensely professional. The Bachelor of Fine Arts is offered in Music Composition, Music Performance, and Music and Technology (a joint degree with the School of Computer Science and the Electrical and Computer Engineering Department) with minors in Collaborative Piano, Conducting, Music Education, Music Performance, and Music Technology available. The Master of Music is offered in Composition, Conducting, Performance, Music Education, and Music and Technology (a joint degree with Computer Science and the Electrical and Computer Engineering Department).

BXA Intercollege Degree Program

Bachelor of Humanities and Arts (BHA), Bachelor of Science and Arts (BSA), Bachelor of Computer Science and Arts (BCSA)

M. Stephanie Murray, Director & Academic Advisor

Location: Solar Decathlon House

www.cmu.edu/interdisciplinary

The **Bachelor of Humanities and Arts (BHA)** is a four-year intercollege degree-granting program designed for students interested in blending studies in the College of Fine Arts and the Dietrich College of Humanities and Social Sciences. The BHA degree combines a General Education requirement, a concentration of courses in the College of Fine Arts, a concentration of courses in the Dietrich College of Humanities and Social Sciences, and free electives. Please refer to Intercollege Programs in this catalog for details.

The **Bachelor of Science and Arts (BSA)** is a four-year intercollege degree-granting program designed for students interested in combining studies in the College of Fine Arts and the Mellon College of Science. It combines General Core requirements, a concentration of courses in the College of Fine Arts, a concentration of courses in the Mellon College of Science, and free electives. Please refer to Intercollege Programs in this catalog for details.

The **Bachelor of Computer Science and Arts (BCSA)** is a four-year intercollege degree-granting program designed for students interested in pursuing fields that comprehensively meld technology and the arts through courses offered in the College of Fine Arts and the School of Computer Science. It combines General Core requirements, a concentration of courses

in the College of Fine Arts, a concentration of courses in the School of Computer Science, and free electives. Please refer to Intercollege Programs in this catalog for details.

The Master of Arts Management Program

1116 Hamburg Hall

The search for both increased support and larger audiences has intensified over the last decade and now, more than ever, arts organizations seek skilled managers. To meet this need, the College of Fine Arts and the Heinz College's School of Public Policy and Management jointly developed the Master of Arts Management (MAM) Program to provide strong leadership in theater companies, dance companies, orchestras, opera companies, museums, galleries and arts policy organizations. In addition to the traditional two-year graduate degree structure, the Master of Arts Management Program provides undergraduate students the opportunity to complete the Bachelor of Fine Arts and Master of Arts Management degrees within a period of five years through the Heinz College's Accelerated Masters Program (AMP). MAM Program alumni can be found managing music and arts service organizations; marketing orchestras, theaters and dance companies; fund-raising for museums, opera companies, ballet companies and public television stations; and managing the finances of university arts departments and private businesses working in the arts and entertainment industry.

Student Defined Majors in the College of Fine Arts

To apply for a Student Defined Major in the College of Fine Arts, one:

1. Must be a student in good standing in the University and have completed at least one semester successfully.
2. Must have a cumulative QPA of 2.75 or better. A student whose QPA is under 2.75 may still submit a proposal. If the proposal is accepted by the Associate Deans, the student must apply for transitional status for the following semester and will have 1 semester to improve his or her QPA to the 2.75 minimum. If the student is not successful in raising the QPA to the 2.75 minimum, he or she may lose the affiliation with the current home department in the College of Fine Arts. If this happens the student must either be re-admitted back into the old program or seek admittance into another department or college.
3. Must have a statement of purpose that explains how and why the proposed course of study will be the best way for the student to receive an education and degree from Carnegie Mellon. This statement should detail the academic backbone of the program and project possible career paths after graduation.
4. Must outline the proposed courses to be taken and the semester in which they might be taken.
5. Must have a faculty mentor in the College of Fine Arts who has agreed to mentor the student through the completion of the degree. This mentor should be from the school where the student is taking the majority of his or her courses, and be approved by the Associate Deans.
6. Once the proposal has been submitted to the Associate Deans and they have reviewed it, the student will be required to go to the academic advisors in the school/schools where he or she will be taking courses and have them sign-off on the courses which are specific to their schools. Once the student has obtained all the necessary signatures, the completed proposal should be returned to CFA 100 for final review and approval by the Associate Deans.

All signed documentation should be submitted to the Office of the Dean of Fine Arts, CFA 100, by May 1 to be effective in the fall semester, and by October 1 to be effective in the spring semester. The proposal will be considered by the Associate Deans of the College, in consultation with the appropriate School Heads and Academic Advisors. Proposals that come in after these dates will be considered, but may not be able to be processed until the following semester. In that case, the student has the option to become a transitional student for a semester.

Under most circumstances the degree conferred at graduation will be a Bachelor of Arts. To continue in the program a student must show academic progress toward the degree. The academic actions of the College will apply to all student-defined majors. The Office of the Dean, in consultation with the faculty mentor and academic advisor, will determine certification of the degree.

Student Organizations

Professional and honorary societies for students in the College of Fine Arts are the American Institute of Architects, Architecture Peer Mentors, Architecture Student Advisory Council, the Design League, American

Institute of Graphic Arts (AIGA), Industrial Designers Society of America (IDSA), United States Institute for Theatre Technology (USITT), Phi Mu Alpha Sinfonia (music fraternity for men), Sigma Alpha Iota (music sorority for women), Pi Kappa Lambda (honorary for students in music) and the Music Educators' National Conference.

Academic Standards

Grading Practices

Grades given to record academic performance in the College of Fine Arts are detailed in the catalog section entitled "Undergraduate Academic Regulations." All courses taught by the schools in the College of Fine Arts follow the standard letter grade system of the university. Responsibility for the grade given the student rests entirely with the instructor and the school concerned. A permanent grade may not be raised by taking a second examination. Students who wish to repeat a course already passed must obtain approval from the Dean of the College. At the time of approval, the Dean will decide in the light of circumstances whether the new grade or the old grade will be the official grade used as the computing factor for honors. Both grades, however, will appear on the official transcript.

Academic Actions

The decision to impose academic action is first initiated at the conclusion of each semester by the School faculty most involved in the student's primary area of study and then presented at the end of the semester to the CFA Academic Advisory Council for confirmation.

A student who is not making satisfactory progress toward meeting professional standards or toward completing graduation requirements in a School may have any of the academic actions listed below imposed by that School even though the student has received "passing" grades.

The academic actions listed below do not follow a particular sequence; any of the actions may be appropriately imposed at any time upon recommendation of the School faculty concerned and confirmation by the CFA Academic Advisory Council.

Warning: For failure to maintain professional standards in a required course; or insufficient evidence of serious application to the professional standards of the School; or an overall quality point average below a satisfactory level. Warning action is intended to notify the student of unsatisfactory performance, and to suggest that the student take steps to determine and correct the cause of the difficulty.

Probation: For failure to pass any professional course as outlined by the faculty of the School; or failure to meet the professional standards of the School although no failing grades are given; or failure to earn the minimum quality point average required to continue in the School. A student on probation may be required to achieve a specified quality point average. The student must improve scholastic standing to an acceptable level in order to be removed from Probation. A student not doing so may be Suspended or Dropped at the end of the semester.

Final Probation: For significantly poor performance, or for continued failure to meet the professional standards of the School. The student must improve scholastic standing to an acceptable level in order to be removed from Final Probation. A student not doing so may be Suspended or Dropped at the end of the semester. This action may be taken without previous academic action.

School Suspension: For poor performance, or for personal problems that create an impediment to professional achievement in the School. A student is suspended from the School, but not the University, when it is deemed in the best interest of the student to allow continuation of study outside of the School during the period of the suspension. The student is not permitted to take courses in the School for a period to be determined by this faculty action, but will be re-admitted at the end of the period of School Suspension specified by the faculty after the condition of the School Suspension is satisfied.

Drop from the School: A student is Dropped from the School when it is clear that the student's progress in professional training is insufficient to warrant continuing in the current professional field of study in this College. This action is taken in the case of a student who has been lacking in some essential requirement in the chosen professional field, but whose general scholastic ability, habits and character justify an opportunity in some other field of education. This action terminates the student's enrollment in the current School, but is not intended to prejudice admission to another Department, School, or College of the University, or to another institution.

This academic action allows the student three choices:

- Transfer to another Carnegie Mellon University Department or School. A student must contact that Department or School of choice to discuss possible transfer.

- Request for Transitional status in the College of Fine Arts for one semester (see below: Transitional Students). A student must make an appointment at the Carnegie Mellon Advising Resource Center in order to pursue this option.
- Withdraw from Carnegie Mellon University. An application for Withdrawal/Leave of Absence form is enclosed with the letter notifying a student of this academic action.

Drop from the College: A student is Dropped from the College when it is clear that the student shows no indication of being able to reach an acceptable level of performance or maintain steady progress toward completing graduation requirements. This action terminates the student's enrollment in the College of Fine Arts, but is not intended to prejudice admission to another College of the University, or to another institution.

This academic action allows the student three choices:

- Transfer to another Carnegie Mellon University College. A student must contact that College of choice to discuss possible transfer.
- Request for Transitional status in the College of Fine Arts for one semester (see below: Transitional Students). A student must make an appointment at the Carnegie Mellon Advising Resource Center in order to pursue this option.
- Withdraw from Carnegie Mellon University. An application for Withdrawal/Leave of Absence form is enclosed with the letter notifying a student of this academic action.

A student who has been suspended from the University or has withdrawn is required to leave the campus, including residence halls and Greek houses, within a maximum of two days after the action and to remain off campus for the duration of the time specified. This action includes exclusion from part-time and summer study at the University for the duration of the period of the action.

Dean's Honor List

Each semester the College of Fine Arts recognizes those students who have attained outstanding semester quality point averages by naming them to the Dean's List. To be eligible, students must complete at least 36 factorable units and have no conditional, missing or failing grades in core classes at the time when final semester grades are recorded. The top 35% of eligible students in each of the College of Fine Arts schools are named to the Dean's List.

Graduation Requirements

Because of the special nature of work in the College of Fine Arts, the first year in all schools should be considered probationary, a period in which a student and faculty can evaluate professional promise in terms of the college's standards. Graduation from the College of Fine Arts follows the general university guidelines. As part of a student's qualification for an undergraduate degree, the equivalent of two terms of full-time work must be pursued under the direction of faculty members in the college during the period immediately prior to the degree award. Courses completed at other institutions will not be acceptable as terminal credit for a degree. Exceptions to this stipulation can be recommended by a school faculty in unusual cases, but the concurrence of the College Council is necessary before final approval of an exception can be given.

To be eligible to graduate, undergraduate students must complete all course requirements for their program with a cumulative Quality Point Average of at least 2.0 for all courses taken. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. Some programs may have additional QPA requirements in order to graduate.

Other graduation requirements in the College of Fine Arts are described in the curriculum of each school. Further questions about specific course requirements and the total number of units required should be directed to the respective school advisors.

Other Regulations Affecting Student Status

Schedule Changes

Courses may be added or dropped within the times stated in the college calendar. No courses may be added or dropped after the stated deadline dates except with the approval of the student's School Head and the Dean of the College. (See Undergraduate Academic Regulations (p. 47) for Add/Drop procedures.)

Withdrawal/Leave of Absence

Please refer to the Student Leave Policy.

Transitional Students

The designation Transitional Student has been instituted by the Dean of the College of Fine Arts to assist students who have been judged unlikely to make satisfactory progress in their chosen professional field, or who on their own initiative, have changed their mind about their originally chosen field of study. Being a Transitional Student gives them an opportunity to maintain a relationship with the College of Fine Arts while re-orienting career plans and goals. It also gives them time to enhance their admissibility to another school in the college, another college in the university, or another institution. Ordinarily a student will be permitted to register as a Transitional Student for no more than one semester.

Transitional status is made available to students upon the advice of their advisors or upon their own request. A student must make an appointment at the Carnegie Mellon Advising Resource Center to discuss this option.

Transfer Students

Undergraduate students seeking transfer within or to any school of the College of Fine Arts must file an application with the School and proceed with the established transfer application procedure, audition, portfolio review or ASAT requirements. Admission may dictate freshman status regardless of the student's prior college experience.

Materials

The college does not furnish students with any drawing materials, make-up materials, textbooks, or other expendable equipment except those in courses in which materials fees are charged to cover specific costs.

Retention of Students' Work

The college reserves the right to retain indefinitely any student work the faculty may select. All work not retained by the faculty must be claimed at the time specified on the bulletin boards of the schools concerned. The college assumes no liability for student materials in its custody.

Minors Offered by the College of Fine Arts

The College of Fine Arts offers minors in Architecture, Art, Design, Drama, and Music to students from other colleges at Carnegie Mellon University. These minors allow students at Carnegie Mellon to take courses and develop a direction for electives in any of the five schools in CFA. Students in the College of Fine Arts may also earn minors outside of their major within other schools in the College. They may also study any of the minors offered by the other colleges to the University at large, thus taking advantage of the broad educational opportunities available at Carnegie Mellon University.

Minors Offered by the College of Fine Arts:

- Architecture
- Architectural History (available also to B. Arch candidates)
- Architectural Representation and Visualization (available also to B. Arch candidates)
- Architectural Technology
- Art
- Building Science (available only to B. Arch candidates)
- Communication Design
- Drama
- History of the Arts
- Industrial Design
- Music
- Music Technology
- Music Theory
- Musicology
- Photography
- Sound Design

Guidelines for students are: 1) except where so designated, CFA students are not eligible to earn a minor in their own school; students from outside CFA may earn a minor in any school in CFA; 2) faculty advisors in the student's home school (in consultation with the academic officer of the other unit involved) will advise students as to the structuring of the courses in each minor; 3) a minor is not to be considered an overload; rather, through the assistance of faculty advisors it should be integrated into a student's overall units required for graduation; 4) the advisors will also monitor the student's development in these minors and keep records in their files which indicate the fulfillment of the course requirements in the minors, as well as in the majors in the student's own school. Courses listed as possible for the minors may be available, but not all courses are offered every semester. Students should consult with their advisors.

Students interested in earning a minor in any of the CFA schools should contact: Architecture: Heather Workinger; Art: Keni Jefferson; Design: Melissa Cicozi; Drama: Amy Nichols; Music: Sharon Johnston.

Minors under Architecture

Minor in Architecture

This sequence is for candidates who intend to develop intellectual links to the architectural profession. The scope of courses offered includes a full spectrum of professional issues in architecture.

Prerequisite Courses	9 units
79-104 Global Histories	9
or 62-110 Passport to the Arts	
Required Courses	18–21 units
48-100 Architecture Design Studio: Foundation I	12
or 48-095 Spatial Concepts for Non-Architects I	
48-240 Historical Survey of World Architecture and Urbanism I	9
Elective Courses*	27 units
48-121 Analog Media I	6
48-126 Analog Media II	6

48-120 Digital Media I	6
48-125 Digital Media II	6
48-215 Materials and Assembly	9
48-324 Structures/Statics	9
48-351 Human Factors in Architecture	9
48-452 Real Estate Design and Development	6
48-453 Urban Design Methods	6
48-383 Ethics and Decision Making in Architecture	6
48-xxx Architecture History (Pre-Approval of coursework required)	9
48-xxx Architecture Elective (Pre-Approval of coursework required)	9

Minimum Units: 54

*Students should consult the Architecture advisor regarding elective choices.

Minor in Architectural History

(available also to B. Arch Candidates)

This sequence is intended for candidates interested in the history of architecture in its many manifestations, including high style and vernacular buildings, western and non-western traditions, built and theoretical works, and rural to urban contexts. Non-architecture majors are required to take 54 units of architectural history. Architecture majors wishing to minor in Architectural History must fulfill the three core required courses in architectural history, plus four additional architectural history electives, for a total of 63 units. Students wishing to pursue the minor should meet with the Architecture advisor to determine if a course is eligible.

Required Courses	18 units
48-240 Historical Survey of World Architecture and Urbanism I	9
48-241 Modern Architecture	9

Elective Courses 36 units/45 units

Students wishing to pursue the minor should meet with the Architecture advisor to determine course eligibility for electives.

Minimum Units: 54 (non architecture majors)

Minimum Units: 63 (architecture majors)

Minor in Architectural Representation and Visualization

This sequence is for candidates who intend to develop particular skills in architectural representation. The Minor in Architectural Representation and Media is intended for those students that want to deepen their knowledge in architectural representation and media and for those who are interested in gaining advanced placement (AMP) in the M.S. programs offered by the School in the areas of Computational Design, Tangible Interaction Design and/or Emerging Media. It is earned by completing the four required media courses and then an additional three elective courses in these areas. Architecture majors wishing to pursue a Minor in Architectural Representation and Visualization must complete the required 33 units and at least an additional 30 units to fulfill the minor for a total of 63 units.

Required Courses	33 units
48-120 Digital Media I	6
48-125 Digital Media II	6
48-121 Analog Media I	6
48-126 Analog Media II	6
Elective Courses	21 units/30 units
48-568 Advanced CAD, BIM, and 3D Visualization	9
48-576 Mapping Urbanism	9

48-724	Scripting and Parametric Design	6
48-3xx	Architectural Drawing Elective (Pre-Approval of coursework required)	9
48-xxx	Architectural Representation/Visualization Elective: (Pre-Approval of coursework required)	9
48-xxx	Architectural Representation/Visualization Elective: (Pre-Approval of coursework required)	9

Minimum Units: 54 (non-architecture majors)

Minimum Units: 63 (architecture majors)

Minor in Architectural Technology

This sequence is for candidates who intend to develop intellectual links to the technical aspects of the profession. It is not available to B. Arch Candidates.

Prerequisite Courses		22 units
33-106	Physics I for Engineering Students	12
21-120	Differential and Integral Calculus	10

Elective Courses		32 units
48-116	Building Physics	9
48-215	Materials and Assembly	9
48-324	Structures/Statics	9
48-315	Environment I: Climate & Energy	9
48-432	Environment II: Advanced Building Systems Integration & Mechanical Systems	9
48-752	Zero Energy Housing	9

Minimum Units: 54

Minor in Building Science

(Available only to B. Arch Candidates)

The Minor in Building Science is intended for those students that want to deepen their knowledge in the building sciences and for those who are interested in gaining advanced placement (AMP) in the M.S. programs offered by the School in the areas of Building Performance & Diagnostics and Sustainable Design. It is earned by completing the two required building technology and three environmental science courses and then an additional three elective courses in the building sciences.

Required Course		12 units
48-722	Building Performance Modeling	12

Elective Courses		45 units
48-795	LEED, Green Design and Building Rating in Global Context	6
48-721	Building Controls and Diagnostics	12
48-723	Performance of Advanced Building Systems	9
48-729	Productivity, Health and the Quality of Buildings	9-12
48-749	Special Topics in CD: Parametric Modeling with BIM	Var.
48-752	Zero Energy Housing	9

Minimum Units: 54

Minors under Art

Minor in Art

Concept Studio (choose one)		10 units
60-101	Concept Studio: The Self and the Human Being	10
60-201	Concept Studio: Space and Time	10
60-202	Concept Studio: Systems and Processes	10

Media Studios (choose two)		20 units
60-110	Electronic Media Studio: Introduction to the Moving Image	10
60-210	Electronic Media Studio: Introduction to Interactivity	10
60-130-60-130	3-D Media Studio I-I Mini 1 and Mini 2 must be in different media.	10
60-131-60-131	3D Media Studio II-II Mini 3 and Mini 4 must be in different media.	10
60-150	2D Media Studio: Drawing	10
60-160	2D Media Studio: Imaging	10
60-250	2D Media Studio: Painting	10

Advanced Media (choose two)		20 units
60-4xx	Advanced ETB: Electives	10
60-4xx	Advanced SIS: Electives	10
60-4xx	Advanced PDP: Electives	10
60-4xx	Advanced CP: Electives	10

Art History/Theory (choose one)		9 units
60-1xx	Art History Elective	9
60-2xx	Art History Elective	9
60-3xx	Art History Elective	9

Minimum units: 59

Minor in the History of Arts

This minor of six or more courses as designated below, will offer students a grouping of Arts History courses that can provide a broad survey in the arts or a highly specialized field. For College of Fine Arts students, all courses meeting the requirements of the Minor in the History of the Arts must be taken outside of their major School, with the exception of the School of Architecture. Interested students should contact Svenja Drouven in the College of Fine Arts, Room 100.

Introductory Level Courses		27 units
(choose at least three, CFA students pick 3 outside of major)		
48-240	Historical Survey of World Architecture and Urbanism I (pre-requisite for all advanced architecture classes below)	9
51-271	How People Work	9
54-239	History of Architecture and Decor 1: Ancients to Gothic	Var.
54-245	History of Clothing	Var.
54-246	History of Clothing 2	Var.
57-173	Survey of Western Music History	9
60-205	Modern Visual Culture 1789-1960	9
60-206	Contemporary Visual Culture 1960 - Present	9

Advanced Courses		27 units
(choose at least three, CFA students pick 3 outside of major)*		
48-340	Modern Architecture and Theory 1900-1945	9
48-341	Expression in Architecture	9
48-348	Architectural History of Mexico & Guatemala	9

48-440	American Regions & Regionalism: An Architectural History of Place, Time, and Cul	9
51-272	Cultures	9
51-378	History of the Book and Printing	6
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-382	History of Drama	3
57-209	The Beatles	9
57-477	Music of the Spirit	6
57-478	Survey of Historical Recording	6
Art History/Theory Special Topics 60-350 to 60-398 (instructor permission only)		9
62-360	Photographers and Photography Since World War II	9
62-371/79-372	Photography, The First 100 Years, 1839-1939	9
79-395	The Arts in Pittsburgh	9
79-396	Music and Society in 19th and 20th Century Europe and the U.S.	9

Minimum units required: 54

* Other courses not on this list may qualify as approved by CFA Dean's Office (College of Fine Arts, Room 100).

Minor in Media Design – IDEATe

The minor in Media Design is offered by the School of Art as part of the Integrative Design, Arts and Technology (IDEATe) network. IDEATe offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students will engage in active “learning by doing” in state-of-the-art maker spaces. The program addresses current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDEATe undergraduate curriculum consists of eight interrelated concentration areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and arts: Game Design, Animation & Special Effects, Media Design, Learning Media, Sound Design, Innovation and Entrepreneurship, Intelligent Environments, and Physical Computing. For more information about the IDEATe network, please see Undergraduate Options (<http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#ideate>).

In the Media Design minor, students learn to design digitally mediated experiences across different platforms, from mobile apps to large-scale installations, and for varied applications, from media for daily living to mediated performances.

Curriculum

Required Courses

One Portal Course

- 15-104 Introduction to Computing for Creative Practice for students in Dietrich College, the College of Fine Arts, and the Tepper School of Business. (DC, CFA, and TSB students may take 15-112 Fundamentals of Programming and Computer Science as a substitute for 15-104.)
- 62-150 Introduction to Media Synthesis and Analysis for students in the College of Engineering, Mellon College of Science, and School of Computer Science.

Four Collaborative or Supportive Courses

54-498	Expanded Theater Fusion Studio	10
60-446	Advanced SIS: Expanded Theater Fusion Studio	10
51-236	Information Design	9
18-099	Special Topics: Mobile App Design & Development	12
15-294	Special Topic: Rapid Prototyping Technologies	5
18-551	Digital Communication and Signal Processing Systems Design	12
62-478	digITool	6
60-110	Electronic Media Studio: Introduction to the Moving Image	10
60-210	Electronic Media Studio: Introduction to Interactivity	10
60-412	Interactive Art and Computational Design	12

60-441	Advanced CP/SIS: Urban Intervention	10
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Electives

Students may take a collaborative or supportive course from one of the other IDEATe areas as one of their four collaborative or supportive courses toward the Media Design minor.

Double-Counting Restriction

Students may double-count two of their Media Design minor courses for other requirements.

Minor in Design

Minor in Design is a great way for students to diversify their studies and incorporate design skills and thinking into their overall academic experiences. Students who are already School of Design majors are not eligible to earn a Design minor. The 54 required units must be unique to the Design minor. No courses may be double counted.

Requirements and Electives

For a design minor, students must complete 54 units: 36 units of required courses, plus 18 units of design electives.

Required Design Courses

Both of these:

51-262	Communication Design Fundamentals: Design for Interactions for Communications (formerly CDF)	9
51-264	Industrial Design Fundamentals: Design for Interactions for Products (formerly IDF)	9

Two of these:

51-171	Placing	9
51-172	Systems	9
51-173	Human Experience in Design	9
51-271	How People Work	9

Two Design Electives:

51-xxx (9 units)

51-xxx (9 units)

Applications

Students must submit transcripts, personal statements, and completed applications by the beginning of February, and submit portfolios or design projects by the beginning of March. They must also obtain permission to complete minors from their major advisors. The minor application form includes detailed requirements.

Admission depends mainly on a student's demonstration of design skills and aptitude. Students are notified of acceptance by the end of March.

If you are interested in applying for the Minor in Design, please contact Design Advisor, Melissa Cicozi <cicozi@cmu.edu>. You can download the Design Project and Application at www.design.cmu.edu, or paper applications are available at the School of Design office, MMCH 110.

Minor in Drama

The Drama minor provides students with a well-rounded opportunity to obtain preliminary professional exposure to the theatre arts. Courses may involve acting, directing, playwriting, design, production technology and management, and dramatic literature courses. Students also become involved with Drama productions by signing up for Production for Non-Majors, which involves evening crew work on various Drama productions.

Admission Requirements

1. Students must apply to enter the program in the office of the Drama Sr. Academic Advisor, Amy Nichols, PCA 223.
2. The student must successfully pass one Drama course prior to being considered for minor status.

Required Courses 25 units

54-163	Production for Non Majors	6
54-164	Production for Non Majors	6
54-175/176	Conservatory Hour	1
54-177	Foundations of Drama I	6
or 54-178	Foundations of Drama I	
54-281	Foundations of Drama II	6
or 54-282	Foundations of Drama II	

Students must meet with the School of Drama Production Manager (PCA 224) for assignments related to Production for Non-Majors.

Elective Courses 30 units

The remainder of the minor is fulfilled with Drama courses of the student's choosing, with approval from the Sr. Academic Advisor in the School of Drama, Amy Nichols. For certain courses, students may need instructor permission to register.

Elective Courses not requiring instructor permission:

54-187/188	Introduction to Playwriting	9
54-189/190	Advanced Playwriting	9
54-191/192	Acting for Non-Majors	9
54-193/194	Comedic Writing for Film and Television	9
54-195/196	Advanced Screenwriting	9

Selected Elective Courses requiring instructor permission:

54-109	Dramaturgy 1: Approaches to Text	9
54-121	Directing I: Sources	9
54-157	Basic PTM	6
54-169	Studiocraft	13
54-171	Basic Design	6

Additional Drama Courses are available by instructor agreement and may require an audition, interview, or portfolio review. Students should contact the Drama Sr. Academic Advisor, Amy Nichols, to inquire about permission for specific courses in which they are interested.

Minimum units required: 55

Minors in Music

Minor in Music

This sequence is for candidates who are majors from any discipline in the university other than music who have some background in music and would like to know more about music.

Admission Requirements:

1. The student must apply to enter the program in the office of the Director of Student Services (CFA 108).

Prerequisite Course 0-3 units

Beginning Piano is required of students who do not pass a piano proficiency test.

57-294	Beginning Piano Test	0
57-329	Beginning Piano for Minors	3

Required Music Courses 25 units

Basic Harmony I and/or Basic Solfege I are required of students who do not qualify for entrance into Harmony I and/or Solfege I, based on their scores on the theory and solfege placement tests.

57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfege I	3
57-173	Survey of Western Music History	9
57-188	Repertoire and Listening for Musicians	1

Required Studio Courses (studio fee is charged) 24 units

57-1xx	Elective Studio	6
57-1xx	Elective Studio	6
57-1xx	Elective Studio	6
57-1xx	Elective Studio	6

Elective Courses 18 units

Elective courses are to be chosen from those courses listed for the School of Music in the current course catalog. Performance electives are encouraged. (An audition is required for all School of Music performance ensembles.)

Minimum units required: 67

Minor in Music Technology

This sequence is for candidates who majors from any discipline in the university who have some background in music and would like to know more about music technology.

Note: Students in the School of Music have slightly different requirements for the Minor in Music Technology. See School of Music (p. 197).

Admission Requirements

The student must apply to enter the program in the office of the Director of Student Services (CFA 108).

Prerequisite Course 0-3 units

Beginning Piano is required of students who do not pass a piano proficiency test.

57-294	Beginning Piano Test	0
57-329	Beginning Piano for Minors	3

Required Music Courses 25 units

Basic Harmony I and/or Basic Solfege I are required of students who do not qualify for entrance into Harmony I and/or Solfege I, based on their scores on the theory and solfege placement tests.

57-152	Harmony I	9
57-161	Eurhythmics I	3
57-173	Survey of Western Music History	9
57-181	Solfege I	3
57-188	Repertoire and Listening for Musicians	1

Sound Recording Courses 21 units

57-337	Sound Recording	6
57-338	Sound Editing and Mastering	6
57-438	Multitrack Recording	9

Music Technology/Sound Courses (choose 3) 21 units

Choose three courses. One of the three courses must be either Introduction to Computer Music or Electronic and Computer Music. (Note that 15-112 is a prerequisite for 15-322; 57-101 or 57-171 is a prerequisite for 57-347.) Other courses may be taken with the permission of the music technology minor advisor.

15-322	Introduction to Computer Music	9
15-323	Computer Music Systems and Information Processing	9
33-114	Physics of Musical Sound	9

54-509	Theatrical Sound System Design	9
54-666	Production Audio	6
57-345	Hacking the Music World	9
57-347	Electronic and Computer Music	6
60-131	3D Media Studio II	5
60-210	Electronic Media Studio: Introduction to Interactivity	10

Minimum units required: 67

Minor in Music Theory

This sequence is for candidates who are majors from any discipline in the university who have some background in music and would like to know more about music theory.

Note: Students in the School of Music have slightly different requirements for the Minor in Music Theory. See School of Music (p. 197).

Admission Requirements

The student must apply to enter the program in the office of the Director of Student Services (CFA 108).

Prerequisite Course 0–3 units

Beginning Piano is required of students who do not pass a piano proficiency test.

57-294	Beginning Piano Test	0
57-329	Beginning Piano for Minors	3

Required Music Courses 25 units

57-152	Harmony I	9
57-161	Eurhythmics I	3
57-173	Survey of Western Music History	9
57-181	Solfege I	3
57-188	Repertoire and Listening for Musicians	1

Required Theory Courses 21 units

57-151	Counterpoint in Theory and Application	6
57-153	Harmony II	9
57-408	Form and Analysis	6

Upper Level Theory Course (choose one) 6 units

See theory courses on the Music Support Courses Two-Year Rotation list. It is available on the Inside Music website:<http://music.cfa.cmu.edu/>. Click on Music Support Course Two-Year Rotation. A graduate course may be taken with the permission of the instructor.

Elective Courses 18 units

Elective courses are to be chosen from those courses listed for the School of Music in the current course catalog.

Minimum units required: 70

Minor in Musicology

This sequence is for candidates who are majors from any discipline in the university who have some background in music and would like to know more about music history.

Admission Requirements

The student must apply to enter the program in the office of the Director of Student Services (CFA 108).

Prerequisite Course 0–3 units

Beginning Piano is required of students who do not pass a piano proficiency test.

57-294	Beginning Piano Test	0
57-329	Beginning Piano for Minors	3

Required Music Courses 15 units

57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfege I	3

Required Musicology Courses 36 units

57-283	Music History I	9
57-284	Music History II	9
57-285	Music History III	9
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3

Upper Level Musicology Course (choose one) 6 units

See musicology courses on the Music Support Courses Two-Year Rotation list. It is available on the Inside Music website:<http://music.cfa.cmu.edu/>. Click on Music Support Course Two-Year Rotation. A graduate course may be taken with the permission of the instructor.

Elective Courses 18 units

Elective courses are to be chosen from those courses listed for the School of Music in the current course catalog.

Minimum units required: 75

Minor in Sound Design – IDeATe

The minor in Sound Design is offered by the School of Music as part of the Integrative Design, Arts and Technology (IDeATe) network. IDeATe offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students will engage in active “learning by doing” in state-of-the-art maker spaces. The program addresses current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDeATe undergraduate curriculum consists of eight interrelated concentration areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and arts: Game Design, Animation & Special Effects, Media Design, Learning Media, Sound Design, Innovation and Entrepreneurship, Intelligent Environments, and Physical Computing. For more information about the IDeATe network, please see Undergraduate Options (<http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#ideate>).

In the Sound Design minor, students create experimental music or explore new, technology-enabled applications and markets for sound design, music creation, and performance.

Curriculum

Required Courses

One Portal Course		Units
18-090	Digital Media Interactions: Signal Processing for the Arts	10

62-150	Introduction to Media Synthesis and Analysis for students in the College of Engineering, Mellon College of Science, and School of Computer Science	10
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Four Collaborative or Supportive Courses

57-344	Experimental Sound Synthesis	9
57-345	Hacking the Music World	9
15-322	Introduction to Computer Music	9
57-347	Electronic and Computer Music	6
60-439	Advanced SIS/CP: Hybrid Instrument Building	10
54-509	Theatrical Sound System Design	9

Electives

Students may take a collaborative or supportive course from one of the other IDEATe areas as one of their four collaborative or supportive courses toward the Sound Design minor.

Double-Counting Restriction

Students may double-count two of their Sound Design minor courses for other requirements.

Minors under CFA Dean's Office

Minor in Photography

The Photography Minor exposes students to the breadth of photography offering experiences in traditional photography (i.e. film exposure and silver printing) to digital shooting and output. The student who takes the Photography Minor will become familiar with photography's craft, its history and significant practitioners, and develop his/her own distinct engagement with the medium.

Students may apply for the Photography Minor after they have taken a CFA or Pittsburgh Filmmakers' beginning photography course. Freshmen should not apply for the minor. Students in four-year undergraduate programs may apply in their sophomore or junior year. Students in five-year undergraduate programs, such as Architecture, may apply in their second, third, or fourth year. Applications are accepted in both the fall and spring semesters. Students will be admitted to the minor based on their aptitude, appropriate level of photography skills, and space availability within the program. Once admitted, students will be assigned a faculty advisor who will help them determine a sequence of courses that best fits their needs and interests.

Application Requirements

The application process for the Photography Minor requires submission of: a completed application form signed by the home department advisor, a personal statement, and a portfolio of photographs. Contact the CFA Photography Administrator, Jamie Gruzka, MM B18, for further information and an application form.

Photography Required Courses (3) minimum 27 units

62/60-141/51-281	Black and White Photography I * **	10
62-241	Black and White Photography II	10
62-142	Digital Photography I	10

Photography Elective (1) minimum 9 units

Choose one (1) additional photography course from the list below in consultation with the photo advisor, or consult Jamie Gruzka for current offerings. Also, photo courses may be taken at Pittsburgh Filmmakers. Please refer to their course catalog that is available in the CFA Dean's Office, CFA 100, or online: pghfilmmakers.org (<http://www.pghfilmmakers.org>)

62-165	Mutable Landscape:	10
62-245	Portrait Photography	10
62-265	Alternative Photo Processes	10
62-325	View Camera	10
62-326	Photographic Narrative	9
62-375	Large Format Photography: The Antiquarian Avant-Garde	10

Photo History Required Course (1)9 units

62-371	Photography, The First 100 Years, 1839-1939 **	9
or 62-360	Photographers and Photography Since World War II	

History, Theory, or Criticism of the Visual Arts Elective (1)9 units

Choose one (1) additional History, Theory or Criticism of the Arts course in consultation with the photo advisor. A second Photo History course (62-360 or 62-371) can be used for this requirement.

* prerequisite for photo courses other than history, theory, and/or criticism course

** or course approved by the photography advisor

Minimum units required: 54

School of Architecture

Stephen R. Lee, AIA, LEED AP, Head
Office: CFA 201
<http://www.soa.cmu.edu>

The School of Architecture (SoA) provides deep immersion in the discipline of architecture, intensified by the broader Carnegie Mellon culture of interdisciplinary innovation and creative inquiry.

We define the discipline of architecture as the integrated pursuit of design creativity, historical perspective, social responsibility, technical expertise, and global environmental leadership. Our undergraduate and graduate degree programs prepare students to be excellent, discipline-defining design thinkers in diverse global contexts.

This world-class architecture education is enhanced by our position within one of the world's leading research and entrepreneurship institutions, and by the foundational premise that architectural excellence demands both rigorous training in fundamentals and the development of unique specializations. Students may extend their core knowledge either through concentration in architecture subdisciplines like sustainable design or computational design, or through interdisciplinary interaction with CMU's other renowned programs—whether the sciences, the humanities, business, or robotics. Though every School of Architecture student graduates with intensive architecture knowledge, no two graduates leave with the same education.

In the twenty-first century, few architecture problems are straightforward. Graduates of SoA excel in the roles architects have performed for centuries—and in new roles catalyzed by the depth and breadth of their education—to create and execute innovative solutions to a huge range of emerging global challenges.

Bachelor of Architecture Program

The NAAB-accredited five-year Bachelor of Architecture (B.Arch) program prepares students to be design-thought leaders in a variety of fields, as well as to continue on their path to licensure in the profession of architecture. The B.Arch program begins with three largely scripted years of studio and coursework, providing students a strong, multifaceted foundation in architectural principles and methods. In the fourth and fifth years, students tailor their studio and course choices to the interests they've honed in their first three years: they may choose to continue a general-studies approach or may concentrate their work more heavily in a specific architectural subdiscipline. All B.Arch graduates are thoroughly prepared to continue toward professional licensure, but the tone of their education is distinctly personal.

Each course required for the B.Arch program falls into one of seven categories, each pursuing a set of specific objectives for student learning:

- **Studio (168 units):** Architectural design studio (prescribed for the first three years and selective thereafter) is the backbone of every semester in the B.Arch program. Students learn to combine rigorously rational and resourcefully creative techniques to identify design problems, collect and analyze data, apply theoretical and practical strategies in creation of a design solution, and evaluate its results through extensive testing; and to describe and work at various points along the continuum between form-finding and form-making. (Courses: Foundation I & II, Elaboration I & II, Integration I & II, Advanced Synthesis Options Thesis/Studio I & II)
- **Critical Practice (42 units):** A multifaceted field of practice, architecture interacts with dynamic social, organizational, economic, professional, and cognitive contexts. In this sequence, students learn to use methods from cognitive psychology to analyze the influence of human factors on design, construction and occupancy; to resolve ethical dilemmas with adjudication strategies based in architectural case study; to demonstrate critical awareness and broad understanding of the factors informing the intelligent resolution of architecture and construction; and to identify the roles of architects, urban designers and planners in shaping the built environment in a global context. (Courses: First Year Seminar: Architecture Edition I & II, Context, Human Factors in Architecture, Real Estate Design and Development, Issue of Practice)
- **Design Tools (24 units):** Drawing and modeling both by hand and with the computer are core skills for developing powers of observation, the ability to think in three dimensions, and the communication of architectural ideas. By using a range of analog and digital design tools to engage in the act of making, students will be able to explore,

analyze, formulate, fabricate, and represent ideas about the built environment. (Courses: Analog Media I & II, Digital Media I & II)

- **Environmental Science (27 units):** Environmental education is one of our highest priorities. In this sequence, students learn to describe first principles of and computational approaches to the lighting and thermal performance of buildings; to demonstrate qualitative and quantitative climate- and environment-responsive strategies (energy conservation, passive heating/cooling, daylighting, natural ventilation); to select, configure, and represent building service systems; and to maintain global awareness of high-performance systems-integration strategies. (Courses: Building Physics, Environment I: Climate & Energy, Environment II: Mechanical Systems for Buildings)
- **History (27 units):** In architectural history courses, students learn to identify chronologically and geographically diverse building styles, building types, and urban plans; to describe the cultural, intellectual and aesthetic contexts surrounding the creation of those buildings and sites; to write clearly and persuasively about the historic built environment; and to demonstrate critical thinking, quality research, and effective information management. In addition to the two-semester Historical Survey of World Architecture, each student completes one elective course on architectural history within the School of Architecture. A minor in architectural history is available to students completing four additional, approved, nine-unit architectural history courses beyond these three required courses. (Courses: Historical Survey of World Architecture and Urbanism, Modern Architecture, Architectural History III)
- **Building Technology (18 units):** We understand technical knowledge as design knowledge and place major emphasis on understanding the state-of-the-art and innovative building structure, enclosure, mechanical, lighting, and interior systems. Students learn to design gravity- and lateral load-resisting systems for buildings; to select, configure and size construction systems in wood, masonry, steel, and concrete; and to distinguish among construction materials with regard to their process of manufacture, their physical properties, their environmental performance, and their methods of selection and specification. (Courses: Materials and Assembly, Structures/Statics)
- **General Studies (135 units):** University coursework in mathematics, physical sciences, social sciences, writing, and history are prerequisite to the School's own offerings. (Courses: Interpretation and Argument, Computing @ Carnegie Mellon, Descriptive Geometry, Fundamentals of Computational Design, University Electives)

Curriculum

First Year: FOUNDATION

48-100	Architecture Design Studio: Foundation I	12
48-025	First Year Seminar: Architecture Edition I	3
48-116	Building Physics	9
48-120	Digital Media I	6
48-121	Analog Media I	6
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
48-105	Architecture Design Studio: Foundation II	12
48-026	First Year Seminar: Architecture Edition II	3
48-125	Digital Media II	6
48-126	Analog Media II	6
48-240	Historical Survey of World Architecture and Urbanism I	9
xx-xxx	University Elective (1)	9

Second Year: ELABORATION

48-200	Architecture Design Studio: Elaboration I	18
48-241	Modern Architecture	9
62-275	Fundamentals of Computational Design	9
xx-xxx	University Elective (2)	9
48-205	Architecture Design Studio: Elaboration II	18

48-215	Materials and Assembly	9
48-351	Human Factors in Architecture	9
62-175	Descriptive Geometry	6

Third Year: INTEGRATION

48-300	Architecture Design Studio: Integration I	18
48-315	Environment I: Climate & Energy	9
48-324	Structures/Statics	9
48-250	Context	9
48-305	Architecture Design Studio: Integration II	18
48-380	Real Estate Design and Development	6
48-381	Issues of Practice	6
48-383	Ethics and Decision Making in Architecture	6
xx-xxx	University Elective (3)	9

Fourth Year: ADVANCED TOPICS

48-400	Advanced Synthesis Options Studio I	18
48-432	Environment II: Advanced Building Systems Integration & Mechanical Systems	9
48-xxx	Architectural History III	9
xx-xxx	University Elective (4)	9
48-405	Advanced Synthesis Options Studio II	18
xx-xxx	University Elective (5)	9
xx-xxx	University Elective (6)	9
48-xxx	School Elective (1)	9
48-497	Thesis Prep	3

Fifth Year: ADVANCED TOPICS

48-500	Advanced Synthesis Options Studio III	18
xx-xxx	University Elective (7)	9
xx-xxx	University Elective (8)	9
xx-xxx	University Elective (9)	9
48-505	Advanced Synthesis Options Studio III	18
48-519	Architecture Design Studio: Thesis II	18
xx-xxx	University Elective (10)	9
xx-xxx	University Elective (11)	9
xx-xxx	University Elective (12)	9

Total number of units required: ¹ 450

Minors in Architecture

Undergraduate students in the SoA can also qualify to earn one of three minors within the subject of architecture. These are the Minor in Architectural History, the Minor in Building Science, and the minor in Architectural Representation and Media.

The Minor in Architectural History is intended for those students that want to deepen their knowledge in architectural history. It is earned by completing the three required architectural history courses and then an additional four elective courses in architectural history.

The Minor in Building Science is intended for those students that want to deepen their knowledge in the building sciences and for those who are interested in gaining advanced placement (AMP) in the M.S. programs offered by the School in the areas of Building Performance & Diagnostics and Sustainable Design. It is earned by completing the two required building technology and three environmental science courses and then an additional three elective courses in the building sciences.

The Minor in Architectural Representation and Media is intended for those students that want to deepen their knowledge in architectural representation and media and for those who are interested in gaining advanced placement (AMP) in the M.S. programs offered by the School in the areas of Computational Design, Tangible Interaction Design and/or Emerging Media. It is earned by completing the four required media courses and then an additional three elective courses in these areas.

Minors in Other Disciplines

Undergraduate architecture students may also earn minors in many of the departments or schools on campus. Generally, a student must take six courses within a specific department or concentration to receive a minor. Students interested in minors must contact the school or department of interest to determine specific requirements or prerequisites. Since students of architecture are required to take fifteen electives (135 units), students can easily complete a minor without adding additional coursework to their curriculum.

Graduate Degree Programs

Carnegie Mellon University is recognized for outstanding contributions to science, technology, management, policy, and the fine arts. The School of Architecture builds on a tradition of interdisciplinary study.

Our faculty's diverse set of backgrounds and commitment to professional practice and scholarly research make for a rich learning experience.

Our graduates hold positions in innovative design practices, research organizations, federal and municipal governments, the building and manufacturing industries, and at leading universities both in the US and abroad.

Our programs reflect a commitment to excellence. Students with motivation and ability receive an outstanding educational opportunity at Carnegie Mellon University's School of Architecture.

The School of Architecture offers seven (7) post-professional Master, and three (3) PhD degrees in the following areas of study:

Master of Science in Architecture

The Master of Science in Architecture (MSA) is a post-professional, research-based degree program intended primarily for practitioners in the building industry who are interested in broadening their knowledge base and skill set for use in professional practice. This program is structured on a 9-month (2 semester) curriculum, allowing those already established in the field to take a leave of absence and return with relatively little discontinuity to their careers.

The MSA program allows each student the freedom to customize his or her own curriculum. While this program is ideal for students seeking to enhance an existing skill set, it can also act as a testing ground where students are able to explore new and varied areas of academic study. Whether one chooses to delve deeply into a focused area of research or acquire a broad overview, students are encouraged to draw from resources both within the School of Architecture and throughout the University.

Master of Science in Computational Design and Doctor of Philosophy in Computational Design

One of the first and best-known Computational Design programs in the US, our legacy continues today. Under the direction of dedicated faculty and in collaboration with other departments in the University, (e.g., School of Computer Sciences and the Department of Civil & Environmental Engineering), our visionary students continue to push for innovation and evolution of the state-of-the art in design technology.

Master of Science in Building Performance and Diagnostics and Doctor of Philosophy in Building Performance and Diagnostics

Building Performance & Diagnostics deals with the comprehensive integration of *building design* and *advanced technology*, as a means of producing high performance architecture. Led by the Center for Building Performance & Diagnostics (CBPD) and housed within the Robert L. Preger Intelligent Workplace (<http://www.cmu.edu/greenpractices/greenign-the-campus/green-buildings/intelligent-workplace.html>), students have the opportunity to gain both diversity and depth of knowledge from world-renowned an experienced faculty.

Master of Urban Design

Building on our legacy of Urban Design, and in partnership with the Remaking Cities Institute (RCI) (<http://www.cmu.edu/rci>), this 12-month, Studio-based Master of Urban Design program emphasizes environmental, economic, social and cultural issues affecting the contemporary metropolis, while providing a comprehensive foundation in design, theory, history, policy, management and technical skill.

Master of Science of Tangible Interaction Design

The Master of Tangible Interaction Design (mTID) is truly an interdisciplinary program that integrates computational intelligence and the physical world.

MTID students make interaction tangible by building and programming working prototypes. Housed in the Computation Design (CoDe) Lab (<http://code.arc.cmu.edu>), and leveraging our state-of-the-art Digital Fabrication (dFab) Lab (<http://www.cmu-dfab.com>), the program cultivates experimentation and collaboration in an intimate studio setting.

Master of Science in Sustainable Design

At the forefront of research in sustainable design and technology for over 35 years, Carnegie Mellon's School of Architecture is recognized internationally for its large core of dedicated faculty, providing a solid foundation from which students can learn how to positively and sustainably affect the future of the built environment. This is a post-professional degree program that integrates Design and Technology to provide a comprehensive knowledge base for professional practice.

Master of Science in Architecture-Engineering Construction Management and Doctor of Philosophy in Architecture-Engineering Construction Management

A joint effort between the School of Architecture and the Department of Civil & Environmental Engineering, the Architecture-Engineering-Construction Management (AECM) programs prepare building delivery professionals for careers in capital project delivery. Graduates are educated to become effective decision makers who can positively impact economic, environmental, and ethical aspects of the built environment through professional management strategies. AECM programs deal with the entire life-cycle of capital projects, from pre-design, to design, construction, commissioning, operation, and maintenance stages. They focus on the integration of design and technology, in particular, advanced information systems, as a means of improving building performance, and eliminating negative environmental impact.

Advanced Standing in Master Degree Programs

The School of Architecture offers a unique opportunity to undergraduate students who wish to pursue a Masters degree in an architecture-related field through the Accelerated Masters Program (AMP). Undergraduate students may apply to the AMP in their 4th year of their architecture education, and if accepted, can apply units earned in their 5th year of their undergraduate architecture degree to their graduate degree. This allows students to graduate with a Masters degree in an accelerated period of time.

Student Advising

At the end of every semester, the faculty reviews each student's progress in all courses. Reviews during the first year are intended to determine a student's capabilities in relation to the study of architecture at Carnegie Mellon University, and the School works with each student to ensure placement within the university if a change is desired. Subsequent reviews monitor and ensure continued progress in all sequences of the program.

Students are urged to meet with their assigned faculty advisor to review their academic progress and plans before each semester. Such meetings are important to take full advantage of elective possibilities within the curriculum, general progress toward graduation, and professional goal setting. Students should also check their progress using the online academic audit in the Student Information Online (SIO).

Study Away Program

The School of Architecture strongly encourages students to study away. The perspective gained through immersion in another culture and language is invaluable. Study abroad can fall into four categories: University Direct Exchanges, University Sponsored Programs, External Programs, and Departmental Summer Programs.

To receive credit for courses taken away, the student must have a C or better (not C-) in the course and have an official translated transcript sent to the School of Architecture. Studio work conducted abroad must be presented to the School Head and Studio Coordinator for approval.

Students should make the decision to study away by the fall of their third year, so they can plan their courses accordingly. Students are allowed one semester away for which they receive studio credit except for those students at approved yearlong direct exchange programs. To qualify for study away, a student must have completed the third-year of their program, have a minimum overall QPA of a 3.00 (or 2.75 for SoA summer study abroad) and be in good academic standing.

Summer Courses

Students can receive credit for passing comparable courses at other institutions with advanced approval from the School. A Transfer Credit Evaluation form must be completed prior to enrollment at the other institution for a course to be considered for transfer.

Faculty

OMER AKIN, Professor – PhD, Carnegie Mellon University; Carnegie Mellon, 1973-.

MARYLOU ARSCOTT, Studio Professor – BArch, Architectural Association; Carnegie Mellon, 2007-.

MARTIN AURAND, Principal Architecture Librarian/Archivist – MLIS, University of Pittsburgh; Carnegie Mellon, 1987-.

AZIZAN AZIZ, Senior Researcher, CBPD – MS Building Performance & Diagnostics, Carnegie Mellon University; Carnegie Mellon, 1997-.

NINA BARBUTO, Adjunct Instructor – MArch, Southern California Institute of Architecture; Carnegie Mellon, 2014-.

JOSHUA BARD, Adjunct Assistant Professor – MArch, University of Michigan; Carnegie Mellon, 2012-.

WILLIAM BATES, Adjunct Associate Professor – MArch, University of Miami; Carnegie Mellon, 2014-.

ERIC BROCKMEYER, Adjunct Assistant Professor – MTID, Carnegie Mellon University; Carnegie Mellon, 2011-.

LEE CALISTI, Adjunct Associate Professor – BArch, Kent State University; Carnegie Mellon, 2002-.

DONALD K. CARTER, Director, Remaking Cities Institute – BArch, Carnegie Mellon University; Carnegie Mellon, 2009-.

ERICA COCHRAN, Assistant Professor and UDream Coordinator – PhD, Carnegie Mellon University; Carnegie Mellon, 2009-.

DOUG COOPER, Andrew Mellon Professor – BArch, Carnegie Mellon University; Carnegie Mellon, 1976-.

LIZA CRUZE, – MArch, Virginia Tech; .

DANA CUPKOVA, Assistant Professor, Lucian & Rita Caste Chair – MArch, UCLA; Carnegie Mellon, 2013-.

GERARD DAMIANI, Associate Professor – BArch, Syracuse University; Carnegie Mellon, 1996-.

STEFANI DANES, Adjunct Professor – MArch, Yale University; Carnegie Mellon, 1986-2001, 2009-.

JEFFREY DAVIS, Adjunct Professor – BS Architecture, University of Illinois, Urbana-Champaign; Carnegie Mellon, 1996-.

DONNA FICCA, Adjunct Assistant Professor – BArch, Virginia Tech; Carnegie Mellon, 2011-.

JONATHAN GOLLI, Adjunct Assistant Professor – MArch, University of Toronto; Carnegie Mellon, 2007-.

MATTHEW HUBER, Adjunct Assistant Professor – BArch, Carnegie Mellon University; Carnegie Mellon, 2014-.

EDDY KIM, Visiting Assistant Professor, George N. Pauley Jr. Fellow – MDes, Harvard University; Carnegie Mellon, 2014-.

JEFF KING, Adjunct Assistant Professor – MArch, Tulane University; Carnegie Mellon, 2005-.

SUZU (ZEKUN) LI, Adjunct Instructor – MUD, Carnegie Mellon University; Carnegie Mellon, 2014-.

NICHOLAS LIADIS, Adjunct Assistant Professor – MArch, University of Detroit; Carnegie Mellon, 2010-.

JENNIFER LUCCHINO, Adjunct Associate Professor – MArch, Rice University; Carnegie Mellon, 2002-.

JAMES O'TOOLE, Adjunct Associate Professor – BArch, Penn State University; Carnegie Mellon, 2008-.

RAMI EL SAMAHY, Assistant Teaching Professor – MArch, Harvard University; Carnegie Mellon, 2006-.

JOHN EBERHARD, Professor Emeritus – M.S., Industrial Management, Massachusetts Institute of Technology; Carnegie Mellon, 1989-.

JEREMY FICCA, Associate Professor, Director dFab Lab – MArch, Harvard University; Carnegie Mellon, 2007-.

JOHN FOLAN, T. David Fitz-Gibbon Associate Professor – MArch, University of Pennsylvania; Carnegie Mellon, 2008-.

KAI GUTSCHOW, Associate Professor – PhD, Columbia University; Carnegie Mellon, 1998-.

VOLKER HARTKOPF, Professor, Director CBPD – PhD, University of Stuttgart; Carnegie Mellon, 1972-.

HAL HAYES, Studio Professor – BArch, Carnegie Mellon University; Carnegie Mellon, 2008-.

DELBERT HIGHLANDS, Professor Emeritus – MArch, Carnegie Mellon University; Carnegie Mellon, 1985-.

JONATHAN KLINE, Adjunct Professor – MFA, Penn State University; Carnegie Mellon, 2002-.

RAMESH KRISHNAMURTI, Professor – PhD, University of Waterloo; Carnegie Mellon, 1989-.

KRISTEN KURLAND, Teaching Professor – BArch, University of Pittsburgh; Carnegie Mellon, 1996-.

KHEE POH LAM, Professor – PhD, Carnegie Mellon University; Carnegie Mellon, 2003-.

STEPHEN LEE, Professor and Head – MArch, Carnegie Mellon University; Carnegie Mellon, 1981-.

DAVID LEWIS, Teaching Professor Emeritus – MArch, Leeds College of Architecture; Carnegie Mellon, 1982-.

CINDY LIMAURO, Professor, Drama – MFA in Lighting Design, Florida State University; Carnegie Mellon, 1987-.

VIVIAN LOFTNESS, University Professor – MArch, Massachusetts Institute of Technology; Carnegie Mellon, 1981-.

ARTHUR LUBETZ, Adjunct Professor – BArch, Carnegie Mellon University; Carnegie Mellon, 1988-.

GERRY MATTERN, Adjunct Professor – B.E., Rose Polytechnic Institute; Carnegie Mellon, 1982-.

MICK MCNUTT, Adjunct Associate Professor – MArch, Syracuse University; Carnegie Mellon, 2007-.

CHRISTINE MONDOR, Adjunct Associate Professor – BArch, Carnegie Mellon University; Carnegie Mellon, 1999-.

IRVING OPPENHEIM, Professor – PhD, Cambridge; Carnegie Mellon, 1972-.

STEPHEN QUICK, Adjunct Professor – MArch, Cornell University; Carnegie Mellon, 2010-.

CHARLES ROSENBLUM, Adjunct Assistant Professor – PhD, University of Virginia; Carnegie Mellon, 2000-.

DIANE SHAW, Associate Professor – PhD, University of California - Berkeley; Carnegie Mellon, 1996-.

SCOTT SMITH, Director, Shop – MFA, Cranbrook; Carnegie Mellon, 1984-.

KENT SUHRBIER, Adjunct Associate Professor – BArch, Carnegie Mellon University; Carnegie Mellon, 2000-.

FRANCESCA TORELLO, Adjunct Associate Professor – PhD, Politecnico Torino; Carnegie Mellon, 2007-.

VAVARA TOULKERIDOU, Adjunct Instructor – PhD, Carnegie Mellon University; Carnegie Mellon, 2013-.

RICHARD TURSKY, Assistant Director, Digital Fabrication Lab – MArch, University of Michigan; Carnegie Mellon, 2014-.

VALENTINA VAVASIS, Adjunct Associate Professor – MBA, Northwestern University; Carnegie Mellon, 2014-.

SPIKE WOLFF, Adjunct Assistant Professor – MArch, SCI-Arc; Carnegie Mellon, 2003-.

HEATHER WORKINGER MIDGLEY, Adjunct Associate Professor – PhD, Indiana University of Pennsylvania; Carnegie Mellon, 2006-.

School of Art

John Carson, Head
Office: College of Fine Arts 300
<http://www.cmu.edu/art>

The university-based undergraduate program offered by the School of Art is designed to develop individuals capable of working as artists in a complex, rapidly changing global culture. The program incorporates an expansive approach to art and acknowledges that "working as artists" leads toward a wide variety of pursuits.

Admission to the undergraduate program is highly competitive. Students must show promise of excellence in both academic and artistic performance. Evidence of creative leadership is a plus.

The art faculty, all practicing artists or scholars, provide an intense, professional learning environment in which students develop close ties with their instructors and each other.

Art students are encouraged to take full advantage of the university environment through exposure to faculty and students in other departments in the College of Fine Arts and throughout the University. They are also encouraged to participate in the numerous cultural opportunities on campus and in the larger Pittsburgh community.

The School of Art maintains a variety of studio and workshop accommodations to make possible its wide range of media offerings. It occupies the top two floors of the College of Fine Arts building, as well as a significant portion of Doherty Hall. Numerous exhibition venues inform or present student work including the Ellis Gallery, The Miller Gallery, and the Frame Gallery, which is managed entirely by students.

The progressive curriculum requires that students attain high levels of knowledge, skill and commitment. The four-year undergraduate program offers one general Bachelor of Fine Arts (B.F.A.) in Art.

Using five categories of courses, the curriculum presents art-making in a unique manner which respects tradition and encourages innovation. The course categories are:

- I. Concept Studios
- II. Media Studios
- III. Advanced Studios
- IV. Academic Art Courses
- V. University Academic Courses

Studio courses comprise over sixty percent of the course of study and academic courses comprise the remainder. The division of the studio curriculum into conceptually-driven and media-driven courses acknowledges that neither concept nor media can be presented independently of one another. This curriculum ensures that all students experience high-quality, consistent training in a variety of approaches.

I. Concept Studios

The Concept Studios are the core of the art curriculum. Students are required to complete five concept studios, but may enroll in additional semesters. Experiences gained in the other four components of the program are integrated into Concept Studios. Themes and topics addressed in Concept Studios include: the self and the human being, space/time, systems/processes, contextual practice, and senior studio.

Freshman and sophomore Concept Studios are organized around structured assignments designed to assist the student in developing a personal, non-medium-specific approach to generating art as well as in learning transferable conceptual skills. The progression from semester to semester leads toward increasing complexity and independence. Contextual Practice Studios embrace the context or social conditions in which an artwork exists, covering a range of methods to making art in the public including street art, interactive social media, environmental art, hacktivism, participatory art, guerilla performance, project-based community art, and urban interventions. In the senior year, the Concept Studios, titled Senior Studio, are devoted to a single student-generated body of work.

II. Media Studios

The Media Studios can be viewed as the foundation courses for the program. Students take a total of seven Media Studios within the freshman and sophomore years. These studios ensure that all students have an exploratory experience with all of the media resources of the school. They also serve as preparation for advanced studio work.

Two-Dimensional Media Studios introduce drawing and imaging during the freshman year, and painting or print media during the sophomore year.

Electronic Media Studios introduce the moving image through video and animation during the freshman year, and interactivity in the sophomore year. Three-Dimensional Media Studios introduce media such as ceramics, welding, wood, metals, kinetic sculpture, and digital fabrication during the freshman year.

III. Advanced Studios

Students take a total of twelve Advanced Studio elective courses over the course of the second semester of the sophomore year and the junior and senior years. These courses address specialized studio work in one of the four artistic concentration areas in the school, which are:

- Drawing, Painting, Print Media, and Photography (DP3)
- Sculpture, Installation, and Site Work (SIS)
- Electronic and Time-Based Work (ETB)
- Contextual Practice (CP)

A minimum of four courses must be taken in one of these concentration areas. One of the twelve Advanced Studio courses must be a College of Fine Arts interdisciplinary course or in one of the Schools outside of Art: Architecture, Design, Drama, Music.

IV. Academic Art Courses

First-semester freshmen are required to take Contemporary Issues Forum (60-104), an introduction to current practices in the visual arts. A three-semester art history/theory survey sequence is then required of all students:

Freshman Year (spring):	Adventures in Arts Time
Sophomore Year (fall):	Modern Visual Culture: 1789-1960
Sophomore Year (spring):	Contemporary Visual Culture: 1960 to the Present

After the sophomore year, students must take two elective academic art courses.

V. University Academic Courses

Eleven academic courses outside of Art are required.

Freshman Year

The student is required to take the following three courses:

Computing @ Carnegie Mellon (99-101), Global Histories (79-104), and Interpretation and Argument (76-101).

After Freshman Year

The student must take one course in each of the following academic areas or "options":

- Humanities and Languages or "Culture Option"
- Math, Science and Engineering or "Technical Option"
- History, Psychology, Economics or "Social Science Option"

The student must then take at least three additional courses from ONE of the academic areas/options listed above.

Finally, the student must take two additional, but unspecified, academic electives.

In selecting courses for the university academic component of the curriculum, students are encouraged to complete a cluster of courses that appeals to and develops their interests as emerging artists. In the process of taking their university electives, students can often simultaneously earn a minor.

Bachelor of Fine Arts (B.F.A.) Curriculum

Below is the recommended distribution of courses in the four-year B.F.A. curriculum. After the freshman year, students may begin to choose university electives. After the first semester of the sophomore year, students have more options regarding the sequencing and selection of their coursework.

First Year

Fall		Units
60-101	Concept Studio: The Self and the Human Being	10
60-130-60-130	3-D Media Studio I-I Mini 1 and Mini 2 must be in different media.	10
60-150	2D Media Studio: Drawing	10
60-104	Contemporary Issues Forum	6
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
		48

Spring		Units
60-110	Electronic Media Studio: Introduction to the Moving Image	10
60-131-60-131	3D Media Studio II-II Mini 3 and Mini 4 must be in different media.	10
60-160	2D Media Studio: Imaging	10
60-109	Adventures in Arts Time	9
79-104	Global Histories	9
		48

Second Year

Fall		Units
60-201	Concept Studio: Space and Time	10
or 60-202	Concept Studio: Systems and Processes	
60-210	Electronic Media Studio: Introduction to Interactivity	10
60-250	2D Media Studio: Painting	10
or 60-251	2D Media Studio: Print Media	
60-205	Modern Visual Culture 1789-1960	9
xx-xxx	Academic Elective	9
		48

Spring		Units
60-280	Introduction to Contextual Practice	10
60-4xx	Advanced Studio Elective	10
60-4xx	Advanced Studio Elective	10
60-206	Contemporary Visual Culture 1960 - Present	9
xx-xxx	Academic Elective	9
		48

Third Year

Fall		Units
60-4xx	Advanced Studio Elective	10
60-4xx	Advanced Studio Elective	10
60-4xx	Advanced Studio Elective	10
60-3xx	Academic Art Elective	9
xx-xxx	Academic Elective	9
		48

Spring		Units
60-4xx	Advanced Studio Elective	10
60-4xx	Advanced Studio Elective	10
60-4xx	Advanced Studio Elective	10
60-3xx	Academic Art Elective	9
xx-xxx	Academic Elective	9
		48

Fourth Year

Fall		Units
60-401	Senior Studio	10
60-403	Extended Studio or 60-4xx Advanced Studio Elective	10
60-4xx	Advanced Studio Elective	10
xx-xxx	Academic Elective	9
xx-xxx	Academic Elective	9
		48

Spring		Units
60-402	Senior Studio	10
60-403	Extended Studio or 60-4xx Advanced Studio Elective	10
60-4xx	Advanced Studio Elective	10
xx-xxx	Academic Elective	9
xx-xxx	Academic Elective	9
		48

Total Units for the B.F.A. Art Degree **384**

Sophomore and Senior Year Reviews

Students give an overview of their work twice in their four-year course of study. At the end of the sophomore year, students undergo a faculty review of their work to date in the program. A successful review is required for advancement to the junior year.

The senior review affords students in the fall of their final year the opportunity to review, analyze and summarize their work and to engage a faculty committee in discussion about issues that face someone preparing to enter a career in art.

Art Majors Minor or Double Majoring in Another Department

About a third of current B.F.A. Art students pursue a minor or a second major. If students are contemplating this option, they must discuss their plans with academic advisors from the minor or second major department as well as with the School of Art academic advisor.

Study Abroad

Art students are encouraged to spend either a semester of their junior year, or a summer before or after their junior year, in one of many available international programs. These programs include exchange programs sponsored by the School of Art in which a student's financial aid package remains in effect, and programs sponsored by other institutions. International exchange programs currently active include the following:

China	University of Hong Kong, Shatin, Hong Kong
France	Ecole nationale superieure des Beaux-Arts, Paris
Germany	Universitat der Kunste Berlin, Berlin
Israel	Bezalel Academy, Jerusalem
Japan	Tokyo Polytechnic University, Tokyo
Korea	The Korean National University of the Arts, Seoul
New Zealand	Auckland Institute of Technology, Auckland

Programs with other Pittsburgh Institutions

Art students are eligible to take courses at the nearby University of Pittsburgh's History of Art and Architecture Department, at Pittsburgh Filmmakers, and at the Pittsburgh Glass Center. Established agreements with these institutions and other Pittsburgh colleges, universities or centers offer cross-registration opportunities at no additional expense to the student.

BXA Intercollege Degree Programs

Bachelor of Computer Science and Arts (BCSA) Bachelor of Humanities and Arts (BHA) Bachelor of Science and Arts (BSA)

Carnegie Mellon University offers a degree program that combines an Art Focus (11 courses for BHA and BSA, 12 courses for BCSA) with a focus in the Dietrich College of Humanities and Social Sciences, the Mellon College of Science, or the School of Computer Science. The Assistant Head of the School advises BXA majors in selecting courses in the Art Focus. A description of these three programs, and a list of requirements and electives, can be found in the in the BXA Intercollege Degrees Program section of this catalog.

Art Minors

Students from other colleges and departments are eligible to pursue a minor in art. A minor requires six courses in the School of Art, selected from a list of requirements and electives as described in the Minors Offered by the College of Fine Arts section of this catalog.

Master of Fine Arts (M.F.A.) Degree

The School of Art offers a three-year program leading to a Master of Fine Arts in Art. This is a unique program designed to connect art-making to the university at large, and to Pittsburgh communities and organizations. Information about this program is available at the School of Art website: <http://www.cmu.edu/art>.

Master of Arts Management (M.A.M.) Degree

The College of Fine Arts and the Heinz College School of Public Policy and Management co-sponsor a Master of Arts Management degree. Students admitted to the M.A.M. degree program in their junior year may complete both a Bachelor of Fine Arts degree and a Master of Arts Management degree in five years. Students interested in this graduate degree should consult with advisors early in their undergraduate program.

Pre-College Programs

The School of Art maintains two pre-college programs: a Saturday program during the academic year and a six-week program during the summer. These programs are designed to prepare the college-bound high school student for college level work in art. Information on these programs may be obtained by contacting the School of Art.

Full-Time Tenure Track Faculty

KIM BECK, Associate Professor of Art – M.F.A., Rhode Island School of Design; Carnegie Mellon, 2004–.

BOB BINGHAM, Professor of Art – M.F.A., University of California, Davis; Carnegie Mellon, 1993–.

LOWRY BURGESS, Professor of Art – Post-Graduate Degree, Pennsylvania Academy of Fine Arts/University of Pennsylvania; Carnegie Mellon, 1989–.

JOHN CARSON, Regina and Marlin Miller Professor of Art and Head of the School of Art – M.F.A., California Institute of the Arts; Carnegie Mellon, 2006–.

JAMES DUESING, Professor of Art – M.F.A., University of Cincinnati; Carnegie Mellon, 1997–.

ECHO EGGBRECHT, Assistant Professor of Art – M.F.A., Hunter College, CUNY; Carnegie Mellon, 2006–.

ANDREW JOHNSON, Associate Professor of Art – M.F.A., Carnegie Mellon University; Carnegie Mellon, 2004–.

ELAINE A. KING, Professor of Art History and Theory – Ph.D., Northwestern University; Carnegie Mellon, 1981–.

CAROL KUMATA, Professor of Art – M.F.A., University of Wisconsin, Madison; Carnegie Mellon, 1979–.

GOLAN LEVIN, Associate Professor of Art – M.S., Massachusetts Institute of Technology; Carnegie Mellon, 2004–.

JOSEPH MANNINO, Professor of Art – M.F.A., University of Southern Illinois; Carnegie Mellon, 1986–.

CLAYTON MERRELL, Professor of Art – M.F.A., Yale University; Carnegie Mellon, 1998–.

ALI MOMENI, Associate Professor of Art – Ph.D., University of California at Berkeley; Carnegie Mellon, 2012–.

PAOLO PEDERCINI, Associate Professor of Art – M.F.A., Rensselaer Polytechnic Institute; Carnegie Mellon, 2009–.

RICHARD PELL, Associate Professor of Art – M.F.A., Rensselaer Polytechnic Institute; Carnegie Mellon, 2008–.

MARTIN PREKOP, Professor of Art – M.F.A., Rhode Island School of Design; Carnegie Mellon, 1993–.

MELISSA RAGONA, Associate Professor of Visual Culture and Critical Theory – Ph.D., State University of New York at Buffalo; Carnegie Mellon, 2003–.

JON RUBIN, Associate Professor of Art – M.F.A., California College of Arts and Crafts; Carnegie Mellon, 2006–.

DEVAN SHIMOYAMA, Assistant Professor of Art – M.F.A., Yale University; Carnegie Mellon, 2014–.

SUZIE SILVER, Professor of Art – M.F.A., The School of the Art Institute of Chicago; Carnegie Mellon, 1999–.

SUSANNE SLAVICK, Andrew W. Mellon Professor of Art – M.F.A., Tyler School of Art; Carnegie Mellon, 1984–.

Visiting Faculty

JOSHUA REIMAN, Visiting Assistant Professor of Art – M.F.A., Syracuse University; Carnegie Mellon, 2011–.

ANGELA WASHCO, Visiting Assistant Professor of Art – M.F.A., University of California, San Diego; Carnegie Mellon, 2015–.

Full-time Joint Appointments

CHARLEE BRODSKY, Associate Professor of Art and Photography – M.F.A., Yale University; Carnegie Mellon, 1978–.

ROGER DANNENBERG, Senior Research Computer Scientist and Artist – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1982–.

JAMIE GRUZSKA, Special Faculty and CFA Photography Administrator – M.F.A., University of Buffalo; .

JUDITH SCHACHTER, Professor of Anthropology, History, and Art – Ph.D., University of Minnesota; Carnegie Mellon, 1984–.

DYLAN VITONE, Associate Professor, School of Design – M.F.A., Massachusetts College of Art; Carnegie Mellon, 2006–.

Adjunct Courtesy Appointments

SARAH ELDRIDGE, Adjunct Faculty.

PATRICIA MAURIDES, Adjunct Faculty – M.F.A., Carnegie Mellon University; Carnegie Mellon, 1999–.

School of Design

Terry Irwin, Head
Office: Margaret Morrison Carnegie Hall 110
<http://design.cmu.edu>

Design at Carnegie Mellon

Design is the thoughtful activity that humanizes our environment through visual communication and the shaping of products that help us in our daily lives. Whether in magazines and books, posters and exhibitions, video and film, human-computer interactions, or any of the myriad of everyday products such as furniture, consumer goods, vehicles, or medical equipment, designers play an important role in shaping the form and content of our experience.

Designers are concerned with aesthetics, but they are equally concerned with serving people. This requires more than skill in the fine arts. It also requires knowledge about the needs, desires, expectations, and capabilities of human beings. It requires skills of observation and interpretation that help us understand the people that we want to serve. More than this, however, designers must also understand the technological issues that stand behind effective products. They must understand the materials, tools, and production processes of the modern world. An education in design is an education for the mind as well as the eye and hand.

The undergraduate program enables students to develop specialized skills in the areas of Product (Industrial) Design, Communication (Graphic) Design and Environments (design for physical and digital environments), while providing them with a solid foundation in design studies. Students study systems thinking; the ability to see and solve problems at multiple levels of scale, and situate their work within larger social and environmental contexts.

The over-arching theme of the curricula is *design for interactions*, which acknowledges that 'ecologies' of products and communications often come together within complex physical and digital environments. Coursework balances making and theory with the integration of new, emergent technologies. Students are encouraged to explore the scope of design as well as the responsibility and ethics involved in the design of interactions between people, the built world, and the environment.

The curriculum is one that provides students with the ability to customize their degree: they may choose to specialize in one of three areas offered (Products, Communications, Environments), but also have the option of combining any two, to create a unique, interdisciplinary design degree.

The undergraduate curriculum also introduces students to three important areas of design focus: design for service, design for social innovation and transition design. These represent both new and established design approaches to framing and solving problems. In their senior year, students bring their disciplinary specialty (communications, products or environments) to projects that are situated within the areas of design for service and/or design for social innovation.

The School offers a Bachelor of Design with tracks in Communications, Products, or Environments.

Communications

The ability to communicate and shape meaning is one of the most powerful and ubiquitous forms of design in today's world. Students learn to design effective communications across a wide variety of media that *always* exist within complex webs of interactions between people, products, and environments. Areas of study include narrative and storytelling, information design, and a variety of analog and digital visualization techniques. Students develop the ability to identify specific audiences and communicate to them through effective visual, verbal and aural communications that educate, inform and delight.

They study the dynamic and 'emergent' characteristics of communications in a globally networked society where technologies and modes of individual and mass communication are constantly changing. Students learn systems thinking and engage in an iterative, multi-disciplinary and collaborative design process that involves research, observation, prototyping and rigorous evaluation. Students develop the ability to identify and communicate to specific audiences through effective visual and verbal communications that educate, inform, delight and invite participation.

Products

Students learn to design products and their interactions within the context of human needs and they develop a deep understanding of the ways in which products shape behavior. Our curriculum acknowledges that no product exists in isolation—it is *always* part of a larger system comprised of people, communications and environments. Within the context of design for service, products exist as 'touchpoints' in a service ecology. For this reason, students learn systems thinking and engage in an iterative, multi-disciplinary and collaborative design process that involves research, observation, modeling/prototyping and rigorous evaluation.

Students are introduced to current production and manufacturing processes as well as sustainable approaches, such as cradle-to-cradle, lifecycle analysis and the use of new, more environmentally friendly materials. The School has a well-equipped analog and digital prototyping facility where students work with traditional materials such as wood and metal and learn to design and prototype using CAD software and 3D digital printers.

Environments

Students learn to design for complex environments that exist in the digital, physical and multi-modal realms. Most of the products and communications we interact with are situated within complex physical spaces (our homes, classrooms, places of business, shopping malls, even amusement parks). We also interact with complex online environments such as large websites, social networking and virtual reality environments. And increasingly we interact in 'smart' physical spaces with multi-modal communications in a combination of the analog and the digital.

In our curriculum, environments are seen as integrated and dynamic systems that require the design of interactions at multiple levels of scale. Students acquire a diverse set of skills that includes a deep understanding of spatial relationships, designing *with* and *for* emerging, multi-media technologies and an understanding of the cognitive challenges presented by multi-modal spaces.

Students who focus on the design of environments delve deep into systems thinking and systems dynamics and spend time learning to collaborate and lead within multi-disciplinary teams (solving large problems involving complex spaces almost always involves teams of people from different disciplines).

Design Minor Program

The School also offers a minor in Design for well-qualified students. Further information on the minor program is provided earlier in the catalog.

The Design Curriculum

The design curriculum is for students who are interested in full-time undergraduate study leading to entry-level professional employment or advanced graduate study in the areas of Communication Design, Product Design, or Design for Environments. The first year is a period of discovery, where students explore studio projects and supporting courses in the ideas and methods of design practice as well as courses in design studies. The second and third years are a period of concentration and development primarily within the student's area(s) of specialization. The fourth year is a period of integration and advanced study, with studio projects involving teams of students from all areas of design. There are studio courses throughout all four years, supported by departmental electives in the ideas and methods of design practice and other courses in the history, theory, and criticism of design. In addition, the School also requires all students to take a substantial number of general education courses offered by other departments throughout the university. General education is an essential part of the education of a professional designer.

Foundation Year

In their freshmen year, students are introduced to all three areas of design specialty: Product (Industrial), Communication (Graphic) and digital and physical Environments. Here, they explore these unique and complementary areas of design and gain a wide range of skill sets such as systems thinking, iterative process, collaboration and visualization, and work in both two and three dimensional materials as well as digital media.

At the end of their freshman year, students are given the opportunity to begin to focus their interests in two of three design areas (products/

communications/environments) and will eventually decide upon a single area of focus or a dual path of study.

This is the first-year curriculum for all design students.

First Year

Fall

Studio		Units
51-101	Studio: Survey of Design	9
51-103	Design Workshop I	3
Ideas and Methods		Units
51-121	Visualizing	9
Design Studies		Units
51-171	Placing	9
General Education		Units
76-101	Interpretation and Argument	9
85-102	Introduction to Psychology	9
99-101	Computing @ Carnegie Mellon	3

Spring

Studio		Units
51-102	Design Lab	9
51-104	Design Workshop II	3
Ideas and Methods		Units
51-122	Collaborative Visualizing	9
51-132	Introduction to Photo Design 1st mini	4.5
51-134	Photo Design II 2nd mini	4.5
Design Studies		Units
51-172	Systems	9
General Education		Units
79-104	Global Histories	9

Second Year

Following the first-year program, students select two out of three areas of interest: Products[P], Communications[C], Environments[E]. In the fourth semester students select one of the two areas to study more deeply. Students investigate the relationships people form with designed artifacts and the roles that physical, visual, and digital forms play in our lives. They apply what they learn to the design of products, communications, and environments that facilitate interactions. Students are also required to take general education courses to gain a broad vision of many disciplines and fields of knowledge that are relevant to design.

Second Year

Fall

Studio		Units
51-225	Communications Studio I: Understanding Form & Context (Pick two)	4.5, 4.5
or 51-245	Products Studio I: Understanding Form & Context	
or 51-265	Environments Studio I: Understanding Form & Context	
Ideas and Methods		Units
51-227	Prototyping Lab I: Communications (Pick two corresponding labs)	4.5, 4.5
or 51-247	Prototyping Lab I: Products	
or 51-267	Prototyping Lab I: Environments	
51-2xx	Design Selective (choose from list)	9
Design Studies		Units
51-271	How People Work	9
General Education		Units
xx-xxx	Academic Elective	9

Spring

Studio		Units
51-228	Communications Studio II: Designing Communications for Interactions	9
or 51-248	Products Studio II: Designing Products for Interactions	
or 51-268	Environments Studio II: Designing Environments for Interaction	
Ideas and Methods		Units
51-208	Research Methods	9
51-239	Prototyping Lab II: Communications	9
or 51-249	Prototyping Lab II: Products	
or 51-269	Prototyping Lab II: Environments	
Design Studies		Units
51-272	Cultures	9
General Education		Units
xx-xxx	Academic Elective	9

Third Year

In the fifth and sixth semesters, students may choose to continue their fourth semester area of focus, or they may choose to study their second area of study from the third semester. Students study how design functions at various levels of scale and degrees of complexity situated in specific contexts. They design products, communications, and environments that function as cohesive systems that live within the built and social worlds.

Third Year

Fall

Studio		Units
51-323	Communications Studio III: Designing for Complex Communication Systems	9
or 51-343	Products Studio III: Designing for Complex Products Systems	
or 51-363	Environments Studio III: Designing for Complex Environment Systems	
Ideas and Methods (Select one Design Elective)		Units
51-321	Photographic Narrative	9
51-231	Calligraphy I	9
51-257	Introduction to Computing for Creative Practices	10
51-349	Visual Notation/Journaling	9
51-322	Advanced Digital Imaging	4.5
51-335	Mapping and Diagraming	9
51-359	Prototyping Tools for Embodying UX Design	9
51-355	Experimental Sketching	4.5
51-399	Junior Independent Study	Var.
Design Studies		Units
51-371	Futures	9
General Education		Units
xx-xxx	Academic Elective	9
xx-xxx	Free Elective	9

Spring

Studio		Units
51-330	Communications Studio IV: Designing Communications for Social Systems	9
or 51-350	Products Studio IV: Designing Products for Social Systems	
or 51-360	Environments Studio IV: Designing Environments for Social Systems	
Ideas and Methods (Select one Design Elective)		Units
51-322	Advanced Digital Imaging	4.5
51-328	Advanced Web Design	9
51-334	Photography, Community & Change	9
51-344	Advanced Digital Prototyping	6
51-346	Production Prototyping	6
51-376	Semantics & Aesthetics	9
51-380	Experiential Media Design	9

51-388	Sharing Economies	9
Design Studies		Units
51-372	Persuasion	9
General Education		Units
xx-xxx	Academic Elective	9
xx-xxx	Free Elective	9

Fourth Year

In the senior year, students work to identify their next steps in professional practice, entrepreneurship, or in academia. They apply their design skills and knowledge to client-based and/or self-defined projects that focus on the design of services or social innovation.

The fall semester features the Design Research Studio, a semester-long project where students work in teams applying skill and knowledge learned in Products, Communications, and/or Environments. In the spring the Capstone Project challenges students to work independently on a semester-long project, deepening their understanding of service or social innovation design principles.

Fourth Year

Fall

Studio		Units
51-481	Design Research Studio: Service Design	12
or 51-491	Design Research Studio: Design for Social Innovation	

Ideas and Methods (Select one Design Elective)		Units
51-379	Information+Interaction+Perception	9
51-423	Pieces 2.0: Social Innovation: Desis Lab	9
51-441	Foundation of BME Design	6
51-451	Fundamentals of Joinery & Furniture Design (I)	9
51-455	DeXign the Future: Human Centered Innovation for Exponential Times	9
51-499	Senior Independent Study	Var.

General Education		Units
xx-xxx	Academic Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9

Spring

Studio		Units
51-480	Capstone Design Project: Service Design	12
or 51-490	Capstone Design Project: Social Innovation	

		12
Ideas and Methods (Select one Design Elective)		Units
51-374	Understanding Perception through Design	9
51-427	Advanced Book Arts Workshop	9
51-434	Experimental Form	9
51-442	BME Design Project	9
51-452	Furniture Design II (II)	9
51-478	Design Fiction & Imaginary Futures	9
51-499	Senior Independent Study	Var.
General Education		Units
xx-xxx	Academic Elective	9
xx-xxx	Free Elective	9

Other Requirements

General education courses should be selected from other departments throughout the university. Students are strongly advised to select a balanced set of general education electives-in addition to Interpretation and Argument, Global Histories and Introduction to Psychology - from three broad areas of study: arts and humanities, social and behavioral sciences, and natural sciences and engineering, including mathematics. While free electives may include studio courses in other departments, academic electives are non-studio (lecture) courses in other departments. Specific recommendations (and general requirements) for electives in all of these areas are available from advisors in the School of Design. The School places strong emphasis on the value of general education for personal growth as well as professional development. General education electives allow a student to obtain a minor in another department or program, such as business, human-computer interaction, IDEATE, engineering, professional and technical writing, or architecture.

Students may enroll for no more than 18 units of independent study courses, and no more than one independent study per semester. A minimum 3.0 GPA is required for independent study. Independent study is permitted only in the third and fourth years of the program. Proposals for independent study courses must be developed jointly by the student and a faculty advisor. Guidelines are available from the School.

A minimum GPA of 2.0 is required to maintain Professional Program status. Grades lower than "C" in required Design courses will result in academic probation, suspension, or drop from the School of Design.

Full-time students are required to enroll for a minimum of 36 units per semester, with 45 units required for expected degree progress (typically five courses per semester). The minimum number of units required for graduation in Design is 360.

Standards

The design curriculum adheres closely to the fundamental professional entry-level standards established by the two leading national design organizations: the American Institute of Graphic Arts (AIGA) and the Industrial Designers Society of America (IDSA).

Applications

The School of Design accepts applications from students who are completing secondary education or who wish to transfer from within Carnegie Mellon University. The School also accepts applications from students who wish to transfer from other institutions. Students applying for the program are asked to either 1) submit a portfolio or 2) complete a design project (available as a PDF on the Design web site) as evidence of design ability. This is considered in balance with evidence of academic ability, based on secondary school grades, SAT scores, class rank, and letters of recommendation. The School also accepts applications for the design minors program for a limited number of spaces. Details are available from the design office.

Faculty

ERIC ANDERSON, Associate Professor of Design - M.A., Ohio State University; Carnegie Mellon, 1998-.

MARK BASKINGER, Associate Professor of Design - M.F.A., University of Illinois; Carnegie Mellon, 2003-.

DANIEL BOYARSKI, Professor of Design - M.F.A., Indiana University School for Design, Kunstgewerbeschule, Basel, Switzerland; Carnegie Mellon, 1982-.

CHARLEE MAE BRODSKY, Professor of Photography - M.F.A., Yale University; Carnegie Mellon, 1978-.

WAYNE CHUNG, Associate Professor of Design - MID, University of the Arts; Carnegie Mellon, 2007-.

JODI FORLIZZI, Professor, joint faculty in Design and Human Computer Interaction Institute - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2000-.

BRUCE HANINGTON, Associate Professor of Design of Environmental and Industrial Design - Master of Environmental and Industrial Design, University of Calgary; Carnegie Mellon, 1998-.

KRISTIN HUGHES, Associate Professor of Design - M.F.A., Virginia Commonwealth University; Carnegie Mellon, 2001-.

AISLING KELLIHER, Associate Professor – M.S. & Ph.D, MIT; Carnegie Mellon, 2012–.

MARK MENTZER, Professor of Drawing – B.F.A., Carnegie Mellon University; Carnegie Mellon, 1975–.

THOMAS L. MERRIMAN, Teaching Professor in Design – B.F.A., Carnegie Mellon University; Carnegie Mellon, 1985–.

STACIE ROHRBACH, Associate Professor of Design – MGD, North Carolina State University; Carnegie Mellon, 2003–.

PETER SCUPELLI, Assistant Professor – MDes & Ph.D, Carnegie Mellon; Carnegie Mellon, 2011–.

STEPHEN J. STADELMEIER, Associate Professor of Design – M.S., Cornell University; Carnegie Mellon, 1977–.

CAMERON TONKINWISE, Associate Professor – Ph.D, University of Sydney; Carnegie Mellon, 2012–.

ANDREW TWIGG, Assistant Teaching Professor – B.A., Allegheny College; Carnegie Mellon, 2014–.

DYLAN VITONE, Associate Professor – M.F.A., Massachusetts College of Art; Carnegie Mellon, 2004–.

JOHN ZIMMERMAN, Associate Professor, joint faculty in Design and Human Computer Interaction Institute – MDes, Carnegie Mellon University; Carnegie Mellon, 2002–.

MATT ZYWICA, Assistant Teaching Professor – B.F.A., University of Illinois; Carnegie Mellon, 2014–.

Courtesy Appointments

LUIS VON AHN, Assistant Professor of Computer Science – Ph.D, Carnegie Mellon University; Carnegie Mellon, 2005–.

JONATHAN CAGAN, George Tallman Ladd Professor of Mechanical Engineering – Ph.D., University of California Berkeley.; .

SUGURU ISHIZAKI, Associate Professor of Rhetoric and Visual Design – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2005–.

DAVID S. KAUFER, Professor of English and Rhetoric – Ph.D., University of Wisconsin; Carnegie Mellon, 1980–.

GOLAN LEVIN, Associate Professor of Art – M.S., Massachusetts Institute of Technology; Carnegie Mellon, 2004–.

Special Faculty

JOSEPH M. BALLAY, IDSA, Professor of Design, Emeritus – M.F.A., Carnegie Mellon University; Carnegie Mellon, 1970-2002–.

ROBERT O. SWINEHART, Professor of Design, Emeritus – M.F.A., Northern Illinois University; Carnegie Mellon, 1974 - 2010–.

School of Drama

Peter Cooke, Head of School
Office: Purnell Center for the Arts, 221
<http://www.drama.cmu.edu>

The information contained in this section is accurate as of July 31, 2015 and is subject to change. Please contact the School of Drama with any questions.

The School of Drama at Carnegie Mellon University is the oldest drama program in the country. CMU Drama offers rigorous, world-class classical training in theater while providing thorough preparation for contemporary media.

As a member of the Consortium of Conservatory Theater Training Programs, the school chooses students to participate in the program based on their potential ability. Every Drama student is treated as a member of a theatrical organization and must acquire experience in all phases of the dramatic arts. Students are also asked to broaden their knowledge through courses in the other colleges of the university. The undergraduate Drama program, which incorporates approximately 200 students, leads to a Bachelor of Fine Arts in Drama. The options available are: Acting, Music Theater, Design, Production Technology and Management, Directing, Dramaturgy, and Theater Studies. The production of plays, a natural extension of demanding class work, is our lab, and constitutes one of the school's major activities. The choice of texts used is determined by the particular needs of current students. Each semester, 15 to 25 lab productions, directed by faculty, guest directors, and advanced students, are presented in our three theater spaces. The labs range from completely mounted, full-length dramatic and musical works to more simply produced directing projects and one-acts. The Drama program is rigorous and exacting, making demands on students that necessitate good health, a willingness to work and a commitment to professional discipline at all times. Because of full daytime class work and heavy production schedules, much production preparation takes place in the evening. Drama students, therefore, are advised to live in residence halls or in the immediate vicinity of the campus.

Acting Option

The Acting option is designed to prepare the student for immediate entry into the profession. It is a sequence-based training program with accumulative skills building upon each other over the course of four years. It is a conservatory training course, and the curriculum focuses primarily on the technique and craft of theater. At the same time it offers skills that are applicable to all media. Courses in acting, voice, speech, movement, and theater history are integral parts of the program at all four levels.

In addition to studio classes, Acting majors are required to take at least one liberal arts class each semester outside the school of drama to expand their intellectual curiosity and worldview.

All students must demonstrate a commitment to growth, show continued progress in their work and in the knowledge of their craft, and show a respect for professional standards in discipline, quality and ethics.

The freshman year is a discovery year and provides an introduction to basic skills-working from self, learning to play objectives and actions and the beginning of character exploration.

In the sophomore year these skills are solidified and deepened as more sophisticated, verbally complex material is introduced, through a focus on in-depth scene study, both contemporary and Shakespeare.

In the junior year students continue to develop their craft by investigating a variety of styles, including Greek, Brecht, and Restoration. Skills are now tested and strengthened through public performance.

The senior year provides a bridge from training to the professional world and offers the opportunity to appear on the School of Drama's main stage.

At the end of the senior year, students are introduced to the profession through Showcase performances in New York City and Los Angeles. The privilege to participate in Showcase is subject to the approval of the School of Drama faculty and as a rule is granted only to students who have obtained the necessary credits for graduation.

Music Theater Option

The students in the Music Theater program share the training philosophy and much of the same curriculum as others in the acting option. In addition, they take courses particular to the demands of Music Theater. These include private voice along with training in a variety of dance techniques (Ballet, Jazz, Tap and Broadway Styles) and music theater styles and skills.

Design Option

Design students are expected to develop artistic ability in the conception and execution of scene, lighting, sound and costume design for plays of all periods under varying theatrical conditions. Students may elect to have a focus on one or two areas but must have a solid background in all four. Freshmen in design receive instruction in drawing and painting, three-dimensional techniques, and in the application of basic design principles through courses in drawing and design. Sophomores learn to apply design principles to the theater through research, play analysis, and studies in the fundamentals of scene, lighting, sound and costume design. Design assignments cover various styles and periods and include the preparation of models, renderings, and working drawings, lighting storyboards, and light plots. Juniors and Seniors take specialized courses in two areas of stage design and are expected to head studio and main-stage production crews. As part of the degree work, juniors may design sets, lights, sound or costumes for a production in the Studio Theater and seniors may design sets, lights, sound or costumes for a Master's thesis show or a main-stage production. Designing for lab productions, both those that are highly resourced and those that are moderately resourced, requires a variety of creative approaches, preparing designers for a variety of real-world situations.

Directing Option

The John Wells Directing Program promotes creativity, intellectual curiosity, a broad and well-rounded understanding of the theater and leadership ability. It provides a detailed exploration of the technique of directing for stage and for camera. The curriculum is designed for those serious about the art of directing and intending to pursue a career in theater, film or television.

Course work in scene design, lighting and costume design develops the students' visual sophistication as well as an understanding of how these elements combine in practical production situations. Stage management skills are studied and practiced. Theater history, criticism, play-writing, play development and theater management classes introduce the student to the wide range of knowledge necessary for directing. There are many avenues open for practical application: scene work in class, a short film written and directed by the students, opportunities in multi-camera directing and a studio project. The broad scope of the directing curriculum encourages the director's interaction with all the theatrical disciplines. Collaboration in all forms, so necessary to the art, is the goal.

Production Technology and Management (PTM) Option

The Production Technology and Management program develops the technologists and managers of the future with an intensive curriculum designed to synthesize academic development and production experience. The curriculum focuses on the production requirements of live performance, in the form of traditional theatrical presentation, while also providing exposure to television, film and emerging technology-based art forms. Integrated in a world class research university environment, the School of Drama is uniquely positioned to contribute to the advancement of the collaborative arts. The goal of the PTM program is to prepare today's students to become tomorrow's leading professionals in the entertainment industry.

All undergraduate students begin with the development of visual and written communication skills. The first four semesters immerse the student in a range of collaborative and individual studies: scenery, costume, sound and lighting design fundamentals; dramatic structure and interpretation; manual and computer-based drafting; perspective and figure drawing, fundamentals of directing; production management and preparation, history of art and history of architecture and décor. The last four semesters focus

in the student's analytical skills within their chosen area of concentration: technical direction or stage/production management.

Technical Directors are offered classes in: material applications, metal working techniques, structural design, scenic crafts, fabrication design and detailing, machinery design, rigging techniques, power system and electronic design fundamentals, introduction to sound design, automation system technology, technical management and production management. Technical Directors may take a single semester internship at an approved regional or commercial producing organization, in lieu of one semester of study. Student selected elective courses, outside the School of Drama, provide balance and breadth to the professional undergraduate education offered in the PTM program of study.

Stage Managers and Production Managers are offered classes in: stage management, production planning and scheduling, theater management, introduction to accounting, cash budgeting, producing for television and film, camera lab, computer applications, technical management, organizational behavior, principles of economics, business communications and production management workshop. Stage and Production Managers may take a single semester internship at an approved regional or commercial producing organization, in lieu of one semester of study. Student selected elective courses, outside the School of Drama, provide balance and breadth to the professional undergraduate education offered in the PTM program of study.

Dramaturgy Option

Dramaturgy is the number-one growth field in the entertainment industry. Dramaturgs are theater insiders who thrive on the process of being behind living theater events. They love reading, writing, and thinking and believe in the power of theater to enlighten, stimulate and entertain audiences. Through Carnegie Mellon University's new and innovative Dramaturgy Option you'll become an expert on historical practices and aesthetic theories behind any text, whether in production or waiting to come alive on stage. You will have the insights to reveal playwrights' intentions and the ability to communicate them to producers, directors, performers, and audiences.

The Dramaturgy adapts traditional, historical, and classic texts for the modern stage; aids directors, designers, and performers in clarifying their insights; collaborates with artistic directors in choosing exceptional repertory; finds social relevance in every work; links audiences with the ideas behind the productions in program notes, lectures, and talk-backs.

You will receive rigorous, highly structured academic and artistic training; broad and deep historical research; intensive study of aesthetic and critical theories; practical, professional-level experience in full scale theater productions; opportunities to develop diversity by studying with Carnegie Mellon University professors in other arts as well as in the sciences and humanities; opportunities to study abroad; opportunities to work with professional companies in the US, Asia, Latin America, Africa, and Europe.

Your career possibilities include literary management; story editing for films and television; production dramaturgy; teaching: developing the talents and insights of students at educational institutions.

Theater Studies Option

The Theater Studies option offers students from any of the School's conservatory areas of specialized study the opportunity to continue developing their theater related skills while expanding their interests to other artistic and academic areas. This option will only be available to Drama students who have completed their sophomore year in the School of Drama (ie: two years of conservatory training). Students are required to write a proposal outlining their interests in the Theater Studies option, and the proposal must be approved by the Head of the School of Drama.

The goal of the Theater Studies option is to enable students to explore the diverse opportunities for which conservatory drama training can be a basis, and to examine the possibility of post graduate education in a new area of specialization after obtaining a BFA in Drama. As the intent of the Theater Studies option is to broaden your experiences, a semester studying abroad or participating in a recommended internship is required for one semester, either in the fall or spring. Individualized courses of study are established for each student in consultation with an appropriate faculty advisor.

Curriculum

The School of Drama curriculum is continuously reviewed and modified in an effort to provide the best conservatory experience for undergraduate students in the School of Drama. The following curriculum is subject to change. Not all requirements are listed, and units are often variable within

each Option based on performances, production assignments, and individual projects.

Acting Option

Freshman Year

Fall		Units
54-011	Warmup	1
54-101	Acting I	10
54-103	Speech I	6
54-105	Voice/Alexander I	5
54-107	Movement I	4
54-110	Text for Actors	2
54-159	Production Symposium I	6
54-175	Conservatory Hour	1
54-177	Foundations of Drama I	6
79-104	Global Histories	9
99-101	Computing @ Carnegie Mellon	3

Spring		Units
54-012	Warmup	1
54-102	Acting I	10
54-104	Speech I	6
54-106	Voice/Alexander I	5
54-108	Movement I	4
54-160	Production Symposium I	6
54-176	Conservatory Hour	1
76-101	Interpretation and Argument	9
xx-xxx	Non-Drama Elective	6-9

Sophomore Year

Fall		Units
54-201	Acting II	12
54-203	Voice and Speech II	5
54-207	Movement II	5
54-211	Actor Dance II	3
54-261	Production Symposium II (in either Fall or Spring)	6
54-281	Foundations of Drama II or H&SS Approved Elective *	6
xx-xxx	Non-Drama Elective	6-9
54-213	Singing for Actors II (Optional)	3

Spring		Units
54-202	Acting II	12
54-204	Voice and Speech II	6
54-208	Movement II	3
54-212	Actor Dance II	3
54-242	Improvisation	2
54-262	Production Symposium II (in either Fall or Spring)	6
54-282	Foundations of Drama II or H&SS Approved Elective *	6
xx-xxx	Non-Drama Elective	6-9
54-214	Singing for Actors II (Optional)	3

Junior Year

Fall		Units
54-301	Acting III	10
54-305	Voice/Alexander III	5
54-307	Movement III	5
54-309	Accents for the Stage	6
54-311	Rehearsal and Performance III	16
54-325	Actor Dance III	2
54-409	Theatre Lab for Undergraduates	4
xx-xxx	Non-Drama Elective	6-9
54-317	Singing for Actors III (Optional)	2

54-327	Junior Auditioning (Optional)	2
Spring		Units
54-302	Acting III	10
54-304	Dialects for the Stage	6
54-306	Voice/Alexander III	5
54-308	Movement III	5
54-312	Rehearsal and Performance III	16
54-326	Actor Dance III	2
xx-xxx	Non-Drama Elective	6-9
54-318	Singing for Actors III (Optional)	2
54-327	Junior Auditioning (Optional)	2

Senior Year

Fall		Units
54-285	Alexander Technique (Optional)	1.5
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-401	Camera Lab	3
54-407	Movement IV	4
54-411	Rehearsal and Performance IV	16
54-413	Showcase	4
54-419	Voice & Speech IV	3
54-493	Business of Acting	4
54-519	Acting for the Camera	6
54-405	Undergraduate Future Stages	6
xx-xxx	Non-Drama Elective	
54-403	Voice Over Acting (Optional)	3
Spring		Units
54-285	Alexander Technique (Optional)	1.5
54-402	Camera Lab	3
54-412	Rehearsal and Performance IV	16
54-414	Showcase	9
54-421	Directing: Text to Stage	3
54-438	Acting IV	3
54-520	Acting for the Camera	6
xx-xxx	Non-Drama Elective	6-9

NON-DRAMA ELECTIVES:

Actors take a minimum of seven Non-Drama Electives, 6-9 units each.

Notes:

* Foundations of Drama II will be taken only one semester in the sophomore year. Sophomore Actors will be required to take an approved Humanities & Social Sciences (HSS) course in the Deitrich College during the semester they are not taking Foundations of Drama II. This H&SS course counts as one of the seven required Non-Drama Electives.

Music Theater Option

Freshman Year

Fall		Units
54-101	Acting I	10
54-103	Speech I	6
54-105	Voice/Alexander I	5
54-107	Movement I	4
54-110	Text for Actors	2
54-123	Ballet I	5
54-125	Music Skills I	4
54-159	Production Symposium I	6
54-175	Conservatory Hour	1
54-500	Voice Lab	5
79-104	Global Histories	9

99-101	Computing @ Carnegie Mellon	3
Spring		Units
54-102	Acting I	10
54-104	Speech I	6
54-106	Voice/Alexander I	5
54-108	Movement I	4
54-124	Ballet I	5
54-126	Music Skills II	4
54-160	Production Symposium I	6
54-176	Conservatory Hour	1
54-178	Foundations of Drama I	6
54-500	Voice Lab	5
76-101	Interpretation and Argument	9

Sophomore Year

Fall		Units
54-201	Acting II	12
54-203	Voice and Speech II	5
54-205	Ballet II	3
54-207	Movement II	Var.
54-217	Jazz II	2
54-219	Music Theatre Literature and Repertoire	4
54-223	Tap II	2
54-261	Production Symposium II (in either Fall or Spring)	6
54-281	Foundations of Drama II or H&SS Approved Elective *	6
54-500	Voice Lab	5
Spring		Units
54-202	Acting II	12
54-204	Voice and Speech II	6
54-206	Ballet II	3
54-208	Movement II	3
54-218	Jazz II	2
54-224	Tap II	2
54-226	Acting a Song	4
54-262	Production Symposium II (in either Fall or Spring)	6
54-281	Foundations of Drama II or H&SS Approved Elective *	6
54-500	Voice Lab	5

Junior Year

Fall		Units
54-301	Acting III	10
54-305	Voice/Alexander III	5
54-309	Accents for the Stage	6
54-311	Rehearsal and Performance III	16
54-313	Ballet III	3
54-315	Jazz III	2
54-319	Cabaret	6
54-323	Tap III	2
54-500	Voice Lab	5

Spring		Units
54-302	Acting III	10
54-304	Dialects for the Stage	6
54-306	Voice/Alexander III	5
54-312	Rehearsal and Performance III	16
54-314	Ballet III	3
54-316	Jazz III	2
54-324	Tap III	2
54-410	Theatre Lab for Undergraduates	4
54-500	Voice Lab	5

Senior Year

Fall		Units
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54-285	Alexander Technique (Optional)	1.5
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-401	Camera Lab	3
54-411	Rehearsal and Performance IV	16
54-413	Showcase	4
54-419	Voice & Speech IV	3
54-415	Broadway Dance Styles	5
54-493	Business of Acting	4
54-500	Voice Lab	5
54-519	Acting for the Camera	6
xx-xxx	Scientific and Quantitative Reasoning Elective **	6
54-407	Movement IV (Optional)	4
Spring		Units
54-285	Alexander Technique (Optional)	1.5
54-402	Camera Lab	3
54-412	Rehearsal and Performance IV	16
54-414	Showcase	9
54-416	Broadway Styles	5
54-438	Acting IV	3
54-500	Voice Lab	5
54-520	Acting for the Camera	6

Notes:

* Foundations of Drama II will be taken only one semester in the sophomore year. Sophomore Music Theater students will be required to take an approved Humanities & Social Sciences (H&SS) course in the Deitrich College during the semester they are not taking Foundations of Drama II.

** Music Theater students are required to take an approved Scientific and Quantitative Reasoning elective. Students usually take FM-111 Art & Science at Pittsburgh Filmmakers to fulfill this requirement.

Design Option

Freshman Year

Fall		Units
54-151	Stagecraft	15
54-157	Basic PTM	6
54-169	Studiocraft	13
54-171	Basic Design	6
54-175	Conservatory Hour	1
54-177	Foundations of Drama I OR	6
99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
Spring		Units
54-152	Stagecraft	11
54-158	Basic PTM 2	6
54-170	Studiocraft	8
54-172	Basic Design	6
54-176	Conservatory Hour	1
54-178	Foundations of Drama I OR	6
99-101	Computing @ Carnegie Mellon	3
79-104	Global Histories	9
xx-xxx	Non-Drama Elective	6-9

Sophomore Year

Fall - ALL DESIGN		Units
54-229	Amy Needs a Name	9
54-231	Design for the Stage	9
54-249	Stagecraft II	14
54-271	Technical Management	6
54-281	Foundations of Drama II or H&SS Approved Elective *	6

54-284	Fundamentals of Directing	6
Spring - ALL DESIGN		Units
54-260	Production Preparation II	Var.
54-282	Foundations of Drama II or H&SS Approved Elective *	6
54-381	Special Topics in Drama: History, Literature and Criticism	6
xx-xxx	Non-Drama Elective	6-9
Spring - SOUND DESIGN (consult with advisor)		Units
54-166	Introduction to Sound Design for Theatre	6
54-666	Production Audio	6
Spring - COSTUME DESIGN (consult with advisor)		Units
54-162	Introduction to Costume Design	6
54-230	Make-Up for Designers	6
54-346	Introduction to Costume Construction	6
54-447	Figure Drawing	3
Spring - SCENIC DESIGN (consult with advisor)		Units
54-250	Introduction to Scenic Design	6
54-386	Scenic Design Skills: 3D Model Making	4
54-392	Scenic Design Skills: 2D Drawing and Rendering	4
54-240	History of Architecture and Decor 2: Renaissance to the 21st Century	Var.
Spring - LIGHTING DESIGN (consult with advisor)		Units
54-252	Introduction to Lighting Design	6
54-368	Production Electrics	6
Spring - VIDEO & MEDIA DESIGN (consult with advisor)		Units
60-110	Electronic Media Studio: Introduction to the Moving Image This is not a non-Drama elective.	10
54-XXX	VMD Foundations	
54-XXX	Design "Co-Option"	
XX-XXX	VMD Interdepartmental Course	

Junior Year

Fall - ALL DESIGN		Units
54-361	Production Preparation III	Var.
54-381	Special Topics in Drama: History, Literature and Criticism (if needed)	6
xx-xxx	Non-Drama Elective	6-9
Fall - SOUND DESIGN (consult with advisor)		Units
54-267	Conceptual Sound Design 1	9
54-389	Composition for Theatrical Sound Design 1	6
54-505	Ear Training	1
54-509	Theatrical Sound System Design	9
Fall - COSTUME DESIGN (consult with advisor)		Units
54-245	History of Clothing	6
54-341	Fundamentals of Costume Design	9
54-373	Draping 1	6
54-511	Millinery I OR	9
54-539	Fabric Dyeing I	9
54-473	Drawing for Theatrical Designers	9
54-239	History of Architecture and Decor 1: Ancients to Gothic	Var.
Fall - SCENIC DESIGN (consult with advisor)		Units
54-237	Scenic Painting I	6
54-239	History of Architecture and Decor 1: Ancients to Gothic	Var.
54-331	Scenic Design: Explorations	9
54-379	Scenic Design Skills: Drafting	4
54-383	Scenic Design Skills: Digital Drawing	4
Fall - LIGHTING DESIGN (consult with advisor)		Units
54-349	Automated Lighting Technology	6
54-351	Theatrical Lighting Design	9

54-367	Lighting Design Skills	3	54-511	Millinery I	9
54-469	Dance Lighting Design	2		OR	
54-478	Television Lighting Design	1	54-539	Fabric Dyeing I	9
Fall - VIDEO & MEDIA DESIGN (consult with advisor)		Units	54-405	Undergraduate Future Stages (optional)	6
54-399	Decoding Media	6	Fall - SCENIC DESIGN (consult with advisor)		Units
54-405	Undergraduate Future Stages	6	54-473	Drawing for Theatrical Designers	9
xx-xxx	VMD Interdepartmental Course		54-431	Scenography	9
54-xxx	Design "Co-option" (for co-option students)		54-405	Undergraduate Future Stages (optional)	6
Spring - ALL DESIGN		Units	Fall - LIGHTING DESIGN (consult with advisor)		Units
54-362	Production Preparation III	Var.	54-469	Dance Lighting Design	2
54-381	Special Topics in Drama: History, Literature and Criticism (if needed)	6	54-478	Television Lighting Design	1
xx-xxx	Non-Drama Elective	6-9	54-491	Concert Lighting Design	9
Spring - SOUND DESIGN (consult with advisor)		Units	54-527	Automated Lighting Workshop	Var.
54-390	Composition for Theatrical Sound Design 2	6	Fall - VIDEO & MEDIA DESIGN (consult with advisor)		Units
54-398	Film Sound Design	9	54-498	Expanded Theater Fusion Studio	10
54-505	Ear Training	1	54-xxx	Design "Co-Option" (for co-option students)	6
54-509	Theatrical Sound System Design	9	54-405	Undergraduate Future Stages	6
Spring - COSTUME DESIGN (consult with advisor)		Units	Spring - ALL DESIGN		Units
54-246	History of Clothing 2	6	54-381	Special Topics in Drama: History, Literature and Criticism (if needed)	6
54-442	Costume Design for the Classics	5	54-462	Production Preparation IV	Var.
54-467	Costume Design with Music	5	54-446	Professional Preparation 2	3
54-447	Figure Drawing	3	xx-xxx	Non-Drama Elective	6-9
54-450	Painting for the Theatrical Designer OR	9	Spring - SOUND DESIGN (consult with advisor)		Units
54-470	Costume Rendering	9	54-372	Theatre for the Ear	6
54-xxx	Costume Crafts Mini (varies each semester)	6	54-397	Sound Design For Interactive Environments & Non-Linear Storytelling	9
54-444	Draping for the Costume Designer II	6	54-505	Ear Training	1
54-240	History of Architecture and Decor 2: Renaissance to the 21st Century	Var.	Spring - COSTUME DESIGN (consult with advisor)		Units
Spring - SCENIC DESIGN (consult with advisor)		Units	54-342	Costume Design for TV and Film	9
54-238	Scenic Painting II	6	54-450	Painting for the Theatrical Designer OR	9
54-240	History of Architecture and Decor 2: Renaissance to the 21st Century	6	54-470	Costume Rendering	9
54-332	Scenic Design: Boot Camp	9	54-xxx	Costume Crafts Mini (varies each semester)	
Spring - LIGHTING DESIGN (consult with advisor)		Units	Spring - SCENIC DESIGN (consult with advisor)		Units
54-352	Theatrical and Opera Lighting Design	4	54-432	Scenic Design: Modern Classical	9
54-369	Lighting Design Skills	3	Spring - LIGHTING DESIGN (consult with advisor)		Units
54-452	Architectural Lighting Design	9	54-352	Theatrical and Opera Lighting Design	4
54-479	Television Lighting Design	2	54-452	Architectural Lighting Design	9
54-524	Dance Lighting Design	3	54-479	Television Lighting Design	2
54-527	Automated Lighting Workshop	Var.	54-524	Dance Lighting Design	3
Spring - VIDEO & MEDIA DESIGN (consult with advisor)		Units	54-527	Automated Lighting Workshop	Var.
54-400	Staging Media	6	Spring - VIDEO & MEDIA DESIGN (consult with advisor)		Units
xx-xxx	VMD Interdepartmental class		54-xxx	Media Design Special Projects	
54-xxx	Design "Co-Option" (for co-options students)		54-xxx	Design "Co-Option" (for co-option students)	
Senior Year			NON-DRAMA ELECTIVES:		
Fall - ALL DESIGN		Units	Designers take a minimum of seven Non-Drama Electives, 6-9 units each.		
54-381	Special Topics in Drama: History, Literature and Criticism (if needed)	6	Notes:		
54-445	Professional Preparation 1	3	* Foundations of Drama II will be taken only one semester in the sophomore year. Sophomore Designers will be required to take an approved Humanities and Social Sciences (H&SS) elective in the Deitrich College during the semester they are not taking Foundations of Drama II. This course counts as one of the required seven Non-Drama Electives.		
54-461	Production Preparation IV	Var.	** All Designers are required to complete Special Topics in Drama: History, Literature and Criticism. It may be taken at any time after Foundations II has been completed. <u>Costume Designers are required to take Special Topics the spring semester of sophomore year.</u>		
xx-xxx	Non- Drama Elective	6-9			
Fall - SOUND DESIGN (consult with advisor)		Units			
54-268	Conceptual Sound Design 2	9			
54-275	History of Sound Design	6			
54-328	Advanced Digital Sound Design Skills	6			
54-505	Ear Training	1			
Fall - COSTUME DESIGN (consult with advisor)		Units			
54-435	Scenography for Costume Designers	5			
54-447	Figure Drawing	3			

Directing Option

Freshman Year

Fall	Units
54-011 Warmup	1
54-101 Acting I	10
54-107 Movement I	4
54-109 Dramaturgy 1: Approaches to Text	9
54-110 Text for Actors	2
54-121 Directing I: Sources	9
54-159 Production Symposium I	6
54-175 Conservatory Hour	1
99-101 Computing @ Carnegie Mellon	3
54-517 Director's Colloquium	1
76-101 Interpretation and Argument	9
Spring	Units
54-012 Warmup	1
54-102 Acting I	10
54-122 Directing I: Sources	9
54-160 Production Symposium I	6
54-176 Conservatory Hour	1
54-184 Dramaturgy 2: Introduction to Production Dramaturgy	9
54-518 Director's Colloquium	1
79-104 Global Histories	9
54-177 Foundations of Drama I	6

Sophomore Year

Fall	Units
54-201 Acting II	12
54-221 Directing II: Fundamentals	9
54-257 Directing: Production II	6
54-281 Foundations of Drama II	6
54-517 Director's Colloquium	1
xx-xxx H&SS Approved Elective *	9
xx-xxx Non-Drama Elective	6-9
54-271 Technical Management (Optional)	6
Spring	Units
54-202 Acting II	12
54-222 Directing II: Fundamentals	9
54-258 Directing: Production II	6
54-330 Introduction to Stage Management	6
54-518 Director's Colloquium	1
xx-xxx Non-Drama Elective	6-9
xx-xxx Non-Drama Elective	6-9

Junior Year

Fall	Units
54-322 Directing III: Future Stages	6
54-331 Scenic Design: Explorations	9
54-357 Directing: Production III	12
54-381 Special Topics in Drama: History, Literature and Criticism	6
54-517 Director's Colloquium	1
xx-xxx Non-Drama Elective	6-9
54-271 Technical Management (Optional)	6
Spring - NYC TEPPER INTERNSHIP SEMESTER	Units
54-xxx Tepper Semester courses	45

Senior Year

Fall	Units
54-239 History of Architecture and Decor 1: Ancients to Gothic (Optional)	Var.

54-381 Special Topics in Drama: History, Literature and Criticism (if needed)	6
54-401 Camera Lab	3
54-409 Theatre Lab for Undergraduates	9
54-431 Scenography	9
54-457 Directing: Production IV **	12
54-517 Director's Colloquium	1
xx-xxx Non-Drama Elective	6-9
xx-xxx Non-Drama Elective	6-9
Spring	Units
54-240 History of Architecture and Decor 2: Renaissance to the 21st Century (Optional)	4
54-410 Theatre Lab for Undergraduates	9
54-422 Directing IV	6
54-458 Directing: Production IV **	10
54-518 Director's Colloquium	1
xx-xxx Non-Drama Elective	6-9
xx-xxx Non-Drama Elective	6-9

NON-DRAMA ELECTIVES:

Directors take a minimum of seven Non-Drama Electives, 6-9 units each.

Notes:

* Sophomore Directors will be required to take an approved Humanities & Social Sciences (H&SS) elective in the Deitrich College. This course will count as one of the seven required Non-Drama Electives.

** One semester of Directing Production IV: Senior Thesis Play is required. Second semester is optional.

Production Technology and Management (PTM) Option

Freshman Year

Fall	Units
54-151 Stagecraft	15
54-157 Basic PTM	6
54-169 Studiocrافت	13
54-171 Basic Design	6
54-175 Conservatory Hour	1
54-177 Foundations of Drama I *	6
or 99-101 Computing @ Carnegie Mellon	
76-101 Interpretation and Argument	9

Spring	Units
54-152 Stagecraft	11
54-158 Basic PTM 2	6
54-170 Studiocrافت	8
54-172 Basic Design	6
54-176 Conservatory Hour	1
54-178 Foundations of Drama I *	6
or 99-101 Computing @ Carnegie Mellon	
79-104 Global Histories	9
xx-xxx Non-Drama Elective	6-9

Sophomore Year

Fall	Units
54-229 Amy Needs a Name	9
54-231 Design for the Stage	9
54-271 Technical Management	6
54-249 Stagecraft II	14
54-281 Foundations of Drama II (or HSS Approved Course) **	6
54-284 Fundamentals of Directing	6
xx-xxx Non-Drama Elective	6-9
Spring - ALL PTM	Units
54-260 Production Preparation II	12

54-272	Scenic Fabrication and Installation	6
54-330	Introduction to Stage Management	6
54-334	Production Resource Management	6
54-282	Foundations of Drama II (or HSS Approved Course) **	6
xx-xxx	Non-Drama Elective	6-9
xx-xxx	Directed Elective	
Spring - PTM TECHNICAL DIRECTION		Units
54-264	Welding	4
54-265	Advanced Fabrication	6
Spring - PTM PRODUCTION/STAGE MANAGEMENT (PM/SM)		Units
54-666	Production Audio	6

Junior Year

Fall - ALL PTM		Units
54-273	Technical Direction I	6
54-333	Production Personnel Management	6
54-361	Production Preparation III	Var.
54-381	Special Topics in Drama: History, Literature and Criticism	6
xx-xxx	Directed Elective	3-12
xx-xxx	Non-Drama Elective	6-9
Fall - PTM TECHNICAL DIRECTION		Units
54-353	Structural Design I ~	9
or 54-366	Physics of Stage Machinery	
54-265	Advanced Fabrication	6
Fall - PTM PM/SM		Units
54-266	Stage Management: Cue Lab	3
54-274	Seminar in Costume Management	3
54-339	Stage Management Seminar	3
54-380	Music Reading for Drama Technicians	3
Spring - ALL PTM		Units
54-362	Production Preparation III	Var.
54-468	Theater Management	6
54-381	Special Topics in Drama: History, Literature and Criticism	6
xx-xxx	Non-Drama Elective	6-9
Spring - PTM TECHNICAL DIRECTION		Units
54-354	Structural Design II ~	9
or 54-365	Machine Design I	
54-378	Technical Direction II	6
xx-xxx	Directed Elective	3-12
Spring - PTM PM/SM		Units
54-340	Stage Management Seminar	3
54-456	Production Management Workshop	3
54-166	Introduction to Sound Design for Theatre	6
54-454	Advanced Topics in Stage Management I- Mini 3	3
54-454	Advanced Topics in Stage Management I- Mini 4	3
54-368	Production Electrics	4

Senior Year

Fall - ALL PTM		Units
54-461	Production Preparation IV	Var.
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-464	PTM Professional Practice	3
xx-xxx	Non-Drama Elective	6-9
Fall - PTM TECHNICAL DIRECTION		Units
54-477	Technical Direction III	6
54-353	Structural Design I ~	9
or 54-366	Physics of Stage Machinery	
xx-xxx	Directed Elective	
Fall - PTM PM/SM		Units
54-439	Stage Management Seminar	3

54-453	Production Management Workshop I	3
54-455	Production Data Manipulation	6
54-277	Negotiation and Conflict Management	3
Spring - ALL PTM		Units
54-462	Production Preparation IV	Var.
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-355	30 Hour OSHA	6
xx-xxx	Non-Drama Elective	6-9
Spring - PTM TECHNICAL DIRECTION		Units
54-354	Structural Design II	9
or 54-365	Machine Design I	
54-376	Entertainment Rigging	3
54-480	Technical Direction IV	6

Spring - PTM PM/SM		Units
54-440	Stage Management Seminar	Var.
54-456	Production Management Workshop	3
54-475	Advanced Topics in Stage Management II- Mini 3	3
54-475	Advanced Topics in Stage Management II- Mini 4	3
54-360	Leadership Workshop: Ethics & Innovation	6

NON-DRAMA ELECTIVES:

PTM students take a minimum of seven Non-Drama Electives, 6-9 units each.

Notes:

* Foundations of Drama I will be taken only one semester in the freshman year. Half of the freshmen PTM students will take it in the fall, the rest will take it in the spring. PTM students take 99-101 Computing @ Carnegie Mellon in the semester they are not taking Foundations of Drama I.

** Foundations of Drama II will be taken only one semester in the sophomore year. Sophomore PTM students will be required to take an approved Humanities and Social Sciences (H&SS) elective in the Deitrich College during the semester they are not taking Foundations of Drama II. This course counts as one of the required seven Non-Drama Electives.

*** All PTM students are required to complete Special Topics in Drama: History, Literature and Criticism. It may be taken at any time after Foundations II has been completed.

~ Classes offered in alternating years.

Dramaturgy Option

Freshman Year

Fall		Units
54-109	Dramaturgy 1: Approaches to Text	9
or 54-184	Dramaturgy 2: Introduction to Production Dramaturgy	
54-121	Directing I: Sources	9
54-175	Conservatory Hour	1
54-177	Foundations of Drama I	6
54-200	Dramaturgy Forum	1
76-101	Interpretation and Argument	9
82-xxx	Foreign Language *	9-12
79-104	Global Histories	9
99-101	Computing @ Carnegie Mellon	3
Spring		Units
54-160	Production Symposium I	6
54-176	Conservatory Hour	1
54-184	Dramaturgy 2: Introduction to Production Dramaturgy	9
or 54-109	Dramaturgy 1: Approaches to Text	
54-282	Foundations of Drama II	6
82-xxx	Modern Language *	9-12
xx-xxx	Directed Elective	
xx-xxx	Non-Dramaturgy Elective (54-122 Directing I recommended)	6-9
54-117	Design Collaboration Project	2

Sophomore Year

Fall		Units
54-xxx	Dramaturgy 3/4/5/6 **	9
54-299	Dramaturgy Production: Practical Observation	Var.
or 54-387	Dramaturgy : Production I	
54-200	Dramaturgy Forum	1
54-245	History of Clothing	Var.
76-xxx	Directed English theory course	9
xx-xxx	Directed Elective	9
xx-xxx	Non-Dramaturgy Elective	6-9
82-xxx	Modern Language, if needed *	9-12
54-239	History of Architecture and Decor 1: Ancients to Gothic (or 54-240 in spring)	Var.
Spring		Units
54-xxx	Dramaturgy 3/4/5/6 **	9
54-xxx	Intro Design course (field of choice)	9
54-299	Dramaturgy Production: Practical Observation	Var.
or 54-387	Dramaturgy : Production I	
54-240	History of Architecture and Decor 2: Renaissance to the 21st Century (in not 54-239 in fall)	Var.
54-209	Lab Review Prep for Dramaturgs and Directors	3
xx-xxx	Directed Elective	9
xx-xxx	Directed Elective	9
xx-xxx	Non-Dramaturgy Elective	6-9
82-xxx	Foreign Language, if needed *	9-12

Junior Year

Fall		Units
54-xxx	Dramaturgy 3/4/5/6 ***	9
54-487	Dramaturgy: Production II	Var.
54-200	Dramaturgy Forum	1
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-463	Dramaturgy Research Hours	Var.
xx-xxx	Directed Elective	9
xx-xxx	Non-Dramaturgy Elective	6-9
Spring		Units
54-xxx	Dramaturgy 3/4/5/6	9
54-488	Dramaturgy: Production II	Var.
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-463	Dramaturgy Research Hours	Var.
xx-xxx	Directed Elective	9
xx-xxx	Directed Elective	9
xx-xxx	Non-Dramaturgy Elective	6-9

Senior Year

Fall		Units
54-xxx	Dramaturgy 3/4/5/6 **	9
54-487	Dramaturgy: Production II	Var.
54-200	Dramaturgy Forum	1
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-463	Dramaturgy Research Hours	Var.
54-489	Dramaturgy: Internship ~	9
xx-xxx	Directed Elective	9
xx-xxx	Non-Dramaturgy Elective	6-9
Spring		Units
54-xxx	Dramaturgy 3/4/5/6 OR **	9
54-254	New Play Collaboration	9
54-200	Dramaturgy Forum	1
54-381	Special Topics in Drama: History, Literature and Criticism	6
54-463	Dramaturgy Research Hours	Var.
54-588	Dramaturgy Production III	Var.

54-490	Dramaturgy: Internship ~	9
xx-xxx	Directed Elective	9
xx-xxx	Directed Elective	9
xx-xxx	Non-Dramaturgy Elective	6-9

DIRECTED ELECTIVES: ENGLISH Units
Dramaturgy students take 7 English courses (one theory course, four 200-300 level, two 400-level)

Sample Recommended English Electives:

76-245	Shakespeare: Tragedies and Histories	9
76-247	Shakespeare: Comedies and Romances	9
76-330	Medieval Literature	9
76-331	Renaissance Literary and Cultural Studies	9
76-335	20th Century American: Mid-20th Century Fiction	9
76-431	Chaucer	9
76-432	Advanced Seminar in African American Studies	9
76-438	Film and Media Studies: Television	9

DIRECTED ELECTIVES: HISTORY Units
Dramaturgy students take at least 3 History courses (two 200-level and one 300-level). One course must focus on history pre-1900, and one must focus on African, Asian, Latin American, or Caribbean studies.

DIRECTED ELECTIVES: EUROPEAN STUDIES Units
Dramaturgy students take one European Studies course (cannot be an English course, but can be a History course)

DIRECTED ELECTIVES: FOREIGN LANGUAGE Units
Dramaturgy students take at least one Foreign Language course at the 200-level or above.

DIRECTED ELECTIVES: DRAMA Units
Dramaturgy students take at least ONE of the following Drama courses:

54-101	Acting I	10
54-187	Introduction to Playwriting	9
54-221	Directing II: Fundamentals	Var.
54-330	Introduction to Stage Management	6

NON-DRAMATURGY ELECTIVES:
Dramaturgy students take a minimum of seven Non-Dramaturgy Electives, 6-9 units each.

Notes:

- * Dramaturgy students starting a modern language at the 100-level should begin in the fall of freshman year.
- ** Dramaturgy 3, 4, 5, and 6 may be taken in any order in the sophomore, junior, and senior year.
- *** Dramaturgy students are required to take a total of 18 units of Special Topics in Drama: History, Literature and Criticism during their junior and senior year.
- ~ Dramaturgy Internship may be completed in the summer, fall, or spring semester of junior senior year.

Faculty

WENDY ARONS, Professor, Dramatic Literature - Ph.D., University of California, San Diego; Carnegie Mellon, 2007-.

NATALIE BAKER-SHIRER, Associate Professor, Voice & Speech - M.F.A., University of Pittsburgh; Carnegie Mellon, 1992-.

CLAUDIA BENACK, Associate Teaching Professor, Music Theatre - M.F.A., Carnegie Mellon; Carnegie Mellon, 1993-.

DICK BLOCK, Teaching Professor, Design - M.F.A., Northwestern University; Carnegie Mellon, 1988-.

DAVID BOEVERS, Associate Professor, Production Technology and Management - M.F.A., Yale University; Carnegie Mellon, 2000-.

C. TODD BROWN, Assistant Teaching Professor, Lighting - B.A., Ohio State University; Carnegie Mellon, 2001-.

JAMES CATON, Associate Teaching Professor, Dance Carnegie Mellon, 1988-.

JUDITH CONTE, Teaching Professor, Dance - B.F.A., University of Wisconsin/Milwaukee; Carnegie Mellon, 1978-.

TOME COUSIN, Assistant Professor, Dance Carnegie Mellon, 2011-.

THOMAS DOUGLAS, Teaching Professor, Voice - M.M., Duquesne University; Carnegie Mellon, 1991-.

JANET MADELLE FEINDEL, Professor, Voice/Alexander - M.F.A., Carnegie Mellon; Carnegie Mellon, 1996-.

ROB HANDEL, Associate Professor, Dramatic Writing - M.F.A., Brown University; Carnegie Mellon, 2009-.

HUGH HANSON, Associate Teaching Professor, Costume Production - M.F.A., University of Hawaii at Manoa; Carnegie Mellon, 2015-.

JED ALLEN HARRIS, Associate Teaching Professor, Directing - M.F.A., Carnegie Mellon; Carnegie Mellon, 1991-.

KEVIN HINES, Associate Teaching Professor, Production Technology & Management - M.F.A., Yale University; Carnegie Mellon, 1998-.

GARY KLINE, Teaching Professor, Voice - B.F.A., Carnegie Mellon; Carnegie Mellon, 1990-.

SUTTIRAT LARLARB, Associate Professor, Design - M.F.A., Yale University; Carnegie Mellon, 2013-.

GREGORY LEHANE, Professor, Directing - M.F.A., Carnegie Mellon; Carnegie Mellon, 1991-.

CINDY LIMAURO, Professor, Lighting Design - M.F.A., Florida State; Carnegie Mellon, 1987-.

BARBARA MACKENZIE-WOOD, Raymond W. Smith Professor, Acting - M.F.A., Carnegie Mellon; Carnegie Mellon, 1986-.

CADEN MANSON, Associate Professor, Directing - B.A., University of Texas, Austin; Carnegie Mellon, 2014-.

MOLLY MCCARTER, Assistant Teaching Professor, Stage Management - M.F.A., Yale School of Drama; Carnegie Mellon, 2014-.

ANTHONY MCKAY, Associate Professor, Acting - B.F.A., Carnegie Mellon; Carnegie Mellon, 1985-.

CATHERINE MOORE, Associate Teaching Professor, Movement - M.F.A., University of Cincinnati, College-Conservatory of Music; Carnegie Mellon, 2000-.

ANNE MUNDELL, Associate Professor, Design - M.F.A., Brandeis University; Carnegie Mellon, 1989-.

SARAH PICKETT, Assistant Professor, Sound Design - M.F.A., Yale University; Carnegie Mellon, 2012-.

JOE PINO, Associate Professor, Sound Design - M.F.A., University of Virginia; Carnegie Mellon, 1999-.

MEGAN RIVAS, Associate Professor, Dramaturgy - M.F.A., University at Austin, Texas; Carnegie Mellon, 2013-.

BRIAN RUSSMAN, Associate Teaching Professor, Costume Production - M.F.A., Ohio State University; Carnegie Mellon, 2009-.

TINA SHACKLEFORD, Associate Teaching Professor - M.F.A., University of California, San Diego; Carnegie Mellon, 2004-.

LARRY SHEA, Associate Professor, Video and Media Design - M.F.A., Massachusetts College of Art; Carnegie Mellon, 2010-.

NARELLE SISSONS, Associate Professor, Design - M.A., Central/St Martins and The Royal College of Art in London, UK; Carnegie Mellon, 2007-.

ANDREW SMITH, Assistant Professor, Acting - M.F.A., University of California, San Diego; Carnegie Mellon, 2014-.

ROBERT THOMSON, Associate Professor, Lighting Carnegie Mellon, 2014-.

SUSAN TSU, Bessie F. Anathan Professor, Costume Design - M.F.A., Carnegie Mellon, 2003-.

DON WADSWORTH, Professor, Voice & Speech - M.F.A., University of Pittsburgh; Carnegie Mellon, 1989-.

KAF WARMAN, Associate Professor, Movement - M.F.A., Goddard College, Ecole; Carnegie Mellon, 1996-.

School of Music

Denis Colwell, Head
Office: The College of Fine Arts 105
<http://music.cmu.edu/>

The School of Music at Carnegie Mellon University offers the best aspects of conservatory training within a great university, combining preparation for a lifetime in performance, composition or music and technology with the advantages of learning in an intense academic environment. Every student in the School of Music is a performance, composition or music and technology major. The School of Music is an accredited institutional member of the National Association of Schools of Music.

Each performance major is challenged to develop through individual instruction with master teachers. The School's relationship with the renowned Pittsburgh Symphony Orchestra is among the strongest conservatory-symphony orchestra relationships in the United States, and Pittsburgh's uniquely strong sense of musical community fosters close relationships with the Pittsburgh Opera, Opera Theater of Pittsburgh, Pittsburgh Ballet Theatre, Pittsburgh Chamber Music Society, and a host of other professional musical organizations.

Regular performing ensembles include the Carnegie Mellon Philharmonic, Wind Ensemble, Baroque Ensemble, Contemporary Ensemble, Jazz Orchestra, Jazz Vocal Ensemble, Chorus, and Opera. Some of the School's ensembles are instrument specific: Chamber Music ensembles and the Percussion Ensemble, among others. Opportunities for performance are stressed – undergraduate performance majors perform junior and senior recitals, chamber music is publicly presented, frequent performance opportunities on and off campus are provided, and community outreach is vigorously supported.

The School of Music has an intense commitment to new music, led by composition faculty, conductors who devote fully rehearsed cycles of the Philharmonic to works by student composers, and studio faculty whose own performing careers regularly feature new works, and including regular performances of student works in almost every Contemporary Ensemble Program, frequent opportunities with the Wind Ensemble and Chorus, and inclusion on student recitals. The School's state-of-the-art recording facilities are an especially important resource for composers beginning their public careers.

All teaching is entrusted to professional faculty — there are no assistant studio teachers or doctoral teaching fellows — and specialists in Musicology, Theory, Counterpoint, Analysis, Composition, Computer Music, Eurhythmics, Solfege, Music Education, Pedagogy, Collaborative Piano and Coaching, Acting and Movement, Diction, Literature and Repertoire, Baroque Music, Chamber Music, Jazz, Conducting, and Recording Science provide a broad and rich platform for comprehensive musical preparation. At the same time, the university provides the greatest possible support for students combining their majors with minors in all disciplines, unique joint degree programs, and double major programs. These opportunities significantly increase a student's career options and marketability in the changing professional world of music.

Facilities

The teaching facilities of the School of Music are located on the ground, main, and mezzanine floors of the College of Fine Arts, on the first floor of Margaret Morrison Hall, and in Skibo Gymnasium. Teaching, rehearsal, and practice rooms are equipped with Steinway pianos. Music students also have access to a state-of-the-art recording studio and music technology cluster. Performances take place in Kresge Recital Hall, Carnegie Music Hall, Alumni Concert Hall, and Mellon Institute Auditorium. The Hunt Library houses a fine collection of books, records, and scores. Listening and conference rooms are also available in the library.

School of Music Options

The School of Music offers a Bachelor of Fine Arts in the following areas:

- Performance (Instrumental, Voice, Piano, Organ)
- Composition

To earn a Bachelor's degree in either of these options, a candidate must satisfactorily fulfill all the requirements of the School of Music.

The School of Music jointly with the School of Computer Science and the Carnegie Institute of Technology offers a Bachelor of Science in the following area:

- Music and Technology

Within the options listed above eligible students may elect specializations in the following areas:

- Dalcroze Eurhythmics Certificate
- Piano Pedagogy Certificate
- Collaborative Piano Minor
- Conducting Minor
- Music Education Certification Minor
- Music Technology Minor
- Music Theory Minor
- Sound Design Minor

Dalcroze Eurhythmics Certificate

This program is designed to prepare teachers in the Dalcroze approach to music learning. The course of study includes eurhythmics, piano improvisation, and Dalcroze pedagogy. Carnegie Mellon undergraduates may enter the Dalcroze Training Program during their junior year. However, the certificate will be granted only upon completion of their undergraduate degree. This program is recommended particularly to students who would like to incorporate Dalcroze principles into their teaching and to those who want to obtain more experience in this field.

Piano Pedagogy Certificate

A two-year program leading to certification in piano pedagogy is open to current Carnegie Mellon keyboard majors. Piano and organ majors learn to teach piano in a closely supervised environment of class piano instruction. This program has received national acclaim as a model of excellence, with Carnegie Mellon children consistently capturing prestigious awards in national piano competitions.

Collaborative Piano Minor

The collaborative piano minor consists of a six-semester sequence of courses designed to give the students experience with vocalists and instrumentalists. There are individual coaching sessions as well as practical experience in vocal and instrumental studios.

Conducting Minor

This program is designed for students who are interested in acquiring conducting skills, in anticipation of either graduate study in conducting or a music education career. It includes required courses in basic conducting techniques for both choral and instrumental ensembles, orchestration, score reading/keyboard harmony, and elective courses in instrumental and vocal methods, diction, and literature and repertoire.

Music Education Certification Minor

Music Education Certification is a five-year program, with courses starting in the sophomore year. Bachelor of Fine Arts candidates who complete this program and pass the Praxis tests will receive Pennsylvania state certification in music (K-12), which is recognized in almost all other states.

Music Technology Minor

The student will take a series of courses which may include electronic and computer music, recording technology, the physics of sound, and computer programming. A rich computer music research environment enables talented students to work as programmers with outstanding faculty researchers, whose current projects are gaining international recognition in the areas of computer music and artificial intelligence.

Music Theory Minor

This program is designed for students who are interested in advanced theory and analysis skills, in anticipation of either graduate study in theory or graduate study that requires a substantial level of theory knowledge. The student will take advanced theory and analysis courses and also support courses in the physics of musical sound and the psychology of music.

Sound Design Minor

Students in the Sound Design concentration will explore the processes and products of digital sound and music. They will receive basic training in key component areas: principles of computer music, hybrid instrument building, concepts in sound design. Combining this training with courses that bring together experts from many disciplines, they will create experimental music or explore new, technology-enabled, applications and markets for sound design, music creation, and performance.

Performances and Activities of the School of Music

The School of Music sponsors performances, master classes, and lectures by outstanding national and international guest artists. Announcements of faculty, student, and guest performances are released every month to the students and the community.

General Requirements for BFA Candidates

Candidates for the Bachelor of Fine Arts degree in composition are required to complete a composition for orchestra in their senior year.

Candidates for the Bachelor of Fine Arts degree in performance are required to give public performances in their junior and senior years. Candidates for the Bachelor of Fine Arts degree in string performance are required to give public performances in their sophomore, junior, and senior years.

Candidates for the Bachelor of Fine Arts degree in performance are required to pass one semester (piano majors must pass two semesters) of a course that includes experience with pedagogy for their major studio area.

- Instrumental majors must take the class for their area to fulfill the Pedagogy Course requirement on the Instrumental curriculum (57-023 Bassoon Studio Performance Class, 57-448 Brass Pedagogy 57-437 Literature and Repertoire, 57-022 Clarinet Studio Performance Class, 57-018 Double Bass Studio Performance Class, 57-020 Flute Studio Performance Class, 57-437 Literature and Repertoire, 57-449 Beginning Piano for Children, 57-021 Oboe Studio Performance Class, 57-030 Percussion Studio Performance Class, 57-016 Viola Studio Performance Class, 57-015 Violin Studio Performance Class).
- Bagpipe, organ and saxophone majors must fulfill the pedagogy requirement as part of satisfying all demands outlined in their Major Studio syllabi, 57-522 Major Studio (Bagpipe), 57-502 Major Studio (Organ) and 57-514 Major Studio (Saxophone).
- Piano majors must take 57-273 Piano Pedagogy I and 57-274 Piano Pedagogy II.
- Voice majors must take 57-010 Voice Studio Performance Class.

Candidates for the Bachelor of Fine Arts degree in applied areas other than piano are required to pass a piano proficiency test.

Candidates for all School of Music degrees are required to pass four repertoire proficiency tests, and to pass a major choral ensemble or a major instrumental ensemble as assigned and to pass Convocation every semester of residence in the School of Music.

Music Curriculum

The music curriculum is based on the following five building blocks:

- Studio
- Theory
- History
- Ensemble
- Academics

1. Studio — This is the heart of the school. Students receive individualized instruction with senior faculty in their major area of study: performance or composition.

2. Theory — These courses are designed to help students develop listening skills, to acquire theoretical knowledge, to recognize structural techniques and manipulate technological resources. It includes courses in sight-reading, ear-training, eurhythmics, harmony, contrapuntal techniques, analysis of musical forms, 20th-21st century techniques, orchestration, score reading, and electronic and computer music for compositional and educational purposes. One music support course in the piano, organ, and instrumental curricula must be a theory course.

3. History - These courses cover in depth the music of the western world and survey the styles and musical structures of non-western music.

4. Ensemble — This area includes student participation in some of the following ensembles: Carnegie Mellon Philharmonic, Wind Ensemble, Baroque Ensemble, Contemporary Ensemble, Jazz Orchestra, Jazz Vocal Ensemble, Chorus, Opera, Chamber Music ensembles, and Percussion Ensemble.

5. Academics — The School of Music requires one general studies course (outside of the School) each semester and six semesters of elective courses for graduation. These accumulated credits may be applied to minors or majors in other disciplines. Exceptional students in good academic and musical standing within the School are permitted to take additional courses beyond the number required for graduation. There is no charge for extra credits taken at Carnegie Mellon. One elective course in the performance curricula must be a course that includes experience with pedagogy for the student's major studio area.

Credits — The total number of units required for graduation is 407 for voice majors; 392 for composition majors; 380 for instrumental, organ, and piano majors. Three units equal one credit.

Piano

First Year

Fall		Units
57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-4xx	Major Ensemble	6
57-193	Collaborative Piano Skills I	3
57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfège I	3
57-189	Introduction to Repertoire and Listening for Musicians	3
57-101	Introduction to Music Technology	6
99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
		55

Spring

57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-4xx	Major Ensemble	6
57-194	Collaborative Piano Skills II	3
57-153	Harmony II	9
57-162	Eurhythmics II	3
57-182	Solfège II	3
57-190	Repertoire and Listening for Musicians I	3
57-283	Music History I	9
79-xxx	Designated History Course	9
		55

Second Year

Fall		Units
57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-4xx	Major Ensemble	6
57-228	Chamber Music: Woodwind and Mixed	3
57-151	Counterpoint in Theory and Application	6
57-163	Eurhythmics III	3
57-183	Solfège III	3
57-289	Repertoire and Listening for Musicians II	3
57-284	Music History II	9
xx-xxx	General Studies Course	6
		49

Spring

57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-4xx	Major Ensemble	6
57-228	Chamber Music: Woodwind and Mixed	3
57-408	Form and Analysis	6

57-164	Eurhythmics IV	3
57-184	Solfege IV	3
57-290	Repertoire and Listening for Musicians III	3
57-285	Music History III	9
xx-xxx	Elective	6
		49

Third Year

Fall		Units
57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-4xx	Major Ensemble	6
57-228	Chamber Music: Woodwind and Mixed	3
57-273	Piano Pedagogy I	6
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	6
		52

Spring		
57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-4xx	Major Ensemble	6
57-228	Chamber Music: Woodwind and Mixed	3
57-274	Piano Pedagogy II	6
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	6
		52

Fourth Year

Fall		Units
57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-xxx	Performance Elective	9
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	3
		43

Spring		
57-100	Convocation	1
57-501	Major Studio (Piano)	9
57-xxx	Performance Elective	9
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	3
		43

Organ

First Year

Fall		Units
57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfege I	3
57-189	Introduction to Repertoire and Listening for Musicians	3
57-101	Introduction to Music Technology	6
99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
		55

Spring

57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-153	Harmony II	9
57-162	Eurhythmics II	3
57-182	Solfege II	3
57-190	Repertoire and Listening for Musicians I	3
57-283	Music History I	9
79-xxx	Designated History Course	9
		55

Second Year

Fall		Units
57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-151	Counterpoint in Theory and Application	6
57-163	Eurhythmics III	3
57-183	Solfege III	3
57-289	Repertoire and Listening for Musicians II	3
57-284	Music History II	9
xx-xxx	General Studies Course	6
		49

Spring		
57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-408	Form and Analysis	6
57-164	Eurhythmics IV	3
57-184	Solfege IV	3
57-290	Repertoire and Listening for Musicians III	3
57-285	Music History III	9
xx-xxx	Elective	6
		49

Third Year

Fall		Units
57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-459	Score Reading/Keyboard Harmony	6
57-xxx	Music Support Course (Theory/History)	12
57-xxx	Pedagogy Course	var.
xx-xxx	General Studies Course	9
xx-xxx	Elective	3
		46

Spring		
57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	9
		46

Fourth Year

Fall		Units
57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-xxx	Performance Elective	3
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9

xx-xxx	Elective	3
		43
Spring		
57-100	Convocation	1
57-502	Major Studio (Organ)	9
57-4xx	Major Ensemble	6
57-xxx	Performance Elective	3
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	3
		43

Voice

A voice major must also complete an advanced language course of at least 9 units. Recommended: a domestic or international program, after the sophomore year, which includes intensive study for credit in the Italian, German, or French language.

First Year

Fall		Units
57-100	Convocation	1
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-467	Production: Crew	3
57-191	Keyboard Studies	3
57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfège I	3
57-221	Italian Diction	3
57-240	Acting I	6
57-111	Movement and Dance I	3
82-161	Elementary Italian I	12
		61

Spring		
57-100	Convocation	1
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-468	Production: Crew	3
57-191	Keyboard Studies	3
57-153	Harmony II	9
57-162	Eurhythmics II	3
57-182	Solfège II	3
57-431	Italian Literature and Repertoire	3
57-241	Acting II	6
57-112	Movement and Dance II	3
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
		61

Second Year

Fall		Units
57-100	Convocation	1
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-191	Keyboard Studies	3
57-163	Eurhythmics III	3
57-183	Solfège III	3
57-189	Introduction to Repertoire and Listening for Musicians	3
82-121	Elementary German I	12
57-223	German Diction	3
57-339	Acting III	6
57-211	Movement and Dance III	3
57-101	Introduction to Music Technology	6
		58

Spring

57-100	Convocation	1
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-191	Keyboard Studies	3
57-164	Eurhythmics IV	3
57-184	Solfège IV	3
57-190	Repertoire and Listening for Musicians I	3
57-283	Music History I	9
57-435	German Literature and Repertoire	3
79-xxx	Designated History Course	9
57-340	Acting IV	6
57-212	Movement and Dance IV	3
		58

Third Year

Fall		Units
57-100	Convocation	1
57-010	Voice Studio Performance Class	0
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-xxx	Production Course	6
57-151	Counterpoint in Theory and Application	6
57-289	Repertoire and Listening for Musicians II	3
57-284	Music History II	9
82-101	Elementary French I	12
57-222	French Diction	3
		55

Spring		
57-100	Convocation	1
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-xxx	Production Course	6
57-408	Form and Analysis	6
57-290	Repertoire and Listening for Musicians III	3
57-285	Music History III	9
57-432	French Literature and Repertoire	3
		43

Fourth Year

Fall		Units
57-100	Convocation	1
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-xxx	Production Course	6
57-220	English Diction	3
57-434	Musical Theatre Literature and Repertoire	3
xx-xxx	Elective	6
		34

Spring		
57-100	Convocation	1
57-500	Major Studio (Voice)	9
57-417	Major Vocal Performance Ensemble	6
57-xxx	Production Course	6
57-436	English/Contemporary Literature and Repertoire	3
57-434	Musical Theatre Literature and Repertoire	3
xx-xxx	Elective	6
		34

Instrumental

A string major must also complete two semesters of Chamber Music in the sophomore year.

First Year

Fall		Units
57-100	Convocation	1
57-xxx	Studio	9

57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfege I	3
57-189	Introduction to Repertoire and Listening for Musicians	3
57-101	Introduction to Music Technology	6
99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9

55

Spring		
57-100	Convocation	1
57-xxx	Studio	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-153	Harmony II	9
57-162	Eurhythmics II	3
57-182	Solfege II	3
57-190	Repertoire and Listening for Musicians I	3
57-283	Music History I	9
79-xxx	Designated History Course	9

55**Second Year**

Fall		Units
57-100	Convocation	1
57-xxx	Studio	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-151	Counterpoint in Theory and Application	6
57-163	Eurhythmics III	3
57-183	Solfege III	3
57-289	Repertoire and Listening for Musicians II	3
57-284	Music History II	9
xx-xxx	General Studies Course	6

49

Spring		
57-100	Convocation	1
57-xxx	Studio	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-408	Form and Analysis	6
57-164	Eurhythmics IV	3
57-184	Solfege IV	3
57-290	Repertoire and Listening for Musicians III	3
57-285	Music History III	9
xx-xxx	Elective	6

49**Third Year**

Fall		Units
57-100	Convocation	1
57-xxx	Studio	9
57-4xx	Major Ensemble	6
57-229	Chamber Music	3
57-xxx	Music Support Course (Theory/History)	12
57-xxx	Pedagogy Course	var.
xx-xxx	General Studies Course	9
xx-xxx	Elective	6

46

Spring		
57-100	Convocation	1
57-xxx	Studio	9
57-4xx	Major Ensemble	6

57-229	Chamber Music	3
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	6

46**Fourth Year**

Fall		Units
57-100	Convocation	1
57-xxx	Studio	9
57-4xx	Major Ensemble	6
57-229	Chamber Music	3
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	3

43

Spring		
57-100	Convocation	1
57-xxx	Studio	9
57-4xx	Major Ensemble	6
57-229	Chamber Music	3
57-xxx	Music Support Course (Theory/History)	12
xx-xxx	General Studies Course	9
xx-xxx	Elective	3

43**Composition**

One music support course is recommended to be Creative Orchestration.

First Year

Fall		Units
57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfege I	3
57-189	Introduction to Repertoire and Listening for Musicians	3
57-101	Introduction to Music Technology	6
99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9

55

Spring		
57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-153	Harmony II	9
57-162	Eurhythmics II	3
57-182	Solfege II	3
57-190	Repertoire and Listening for Musicians I	3
57-283	Music History I	9
79-xxx	Designated History Course	9

55**Second Year**

Fall		Units
57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-151	Counterpoint in Theory and Application	6
57-163	Eurhythmics III	3
57-183	Solfege III	3

57-289	Repertoire and Listening for Musicians II	3
57-284	Music History II	9
57-257	Orchestration I	6
xx-xxx	Elective	6

55

Spring

57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-4xx	Major Ensemble	6
57-191	Keyboard Studies	3
57-408	Form and Analysis	6
57-164	Eurhythmics IV	3
57-184	Solfege IV	3
57-290	Repertoire and Listening for Musicians III	3
57-285	Music History III	9
57-271	Orchestration II	6
57-258	20th-21st Century Techniques	6

55

Third Year

Fall		Units
57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-234	Performance for Composers	3
57-332	Introduction to Conducting	6
57-347	Electronic and Computer Music	6
57-xxx	Music Support Course	6
xx-xxx	General Studies Course	12

43

Spring

57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-236	Performance for Composers	3
57-336	Instrumental/Choral Conducting	6
57-459	Score Reading/Keyboard Harmony	6
57-xxx	Music Support Course	6
xx-xxx	General Studies Course	12

43

Fourth Year

Fall		Units
57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-4xx	Major Ensemble	6
57-xxx	Music Support Course	6
xx-xxx	General Studies Course	9
xx-xxx	Elective	12

43

Spring

57-100	Convocation	1
57-521	Major Studio (Composition)	9
57-4xx	Major Ensemble	6
57-349	Supervised Theory Teaching	6
57-xxx	Music Support Course	6
xx-xxx	General Studies Course	9
xx-xxx	Elective	6

43

Dalcroze Eurhythmics Certificate30 units

57-465	Eurhythmics Applications for Performing and Teaching	6
57-466	Eurhythmics Applications for Performing and Teaching	6
57-691	Dalcroze Pedagogy/Practice Teaching	3
57-692	Dalcroze Pedagogy/Practice Teaching	3

57-350	Dalcroze Piano Improvisation	6
xx-xxx	Creative Movement/Choreography	3
57-641	Dalcroze Research Paper	3
57-642	Dalcroze Research Paper	3

Piano Pedagogy Certificate30 units

57-273	Piano Pedagogy I	6
57-274	Piano Pedagogy II	6
57-275	Piano Pedagogy III	6
57-276	Piano Pedagogy IV	6
57-429	Beginning Piano for Children	6

Bachelor of Science in Music and Technology

The Bachelor of Science in Music and Technology is offered jointly by the School of Music, the School of Computer Science (SCS), and the Carnegie Institute of Technology (CIT).

This program consists of a set of courses that span both music and technology, as well as a capstone composition/design/performance project. Courses in all three areas of study are stipulated in the music and technology undergraduate curriculum and provide for students coming from any of the three areas. In other words, regardless of a student's entry point — an interest in computer science, electrical engineering, or music — the coursework prescribed will allow the student to gain the requisite knowledge and experience in all three areas. Students will work closely with advisors and will be guided in both course selection and capstone projects.

General Requirements 85 units

Seminar

57-570	Music and Technology Seminar (8 semesters for a total of 8 units)	8
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University

99-10x	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
79-104	Global Histories	9

Humanities

xx-xxx	Cognition, Choice and Behavior course	9
xx-xxx	English, History, Modern Languages, Philosophy, or Psychology course	9

Mathematics

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10

Science

33-114	Physics of Musical Sound	9
33-106	Physics I for Engineering Students	12

Electives 33 units

Music Core 87 units

57-152	Harmony I	9
57-153	Harmony II	9
57-408	Form and Analysis	6
57-151	Counterpoint in Theory and Application	6
57-258	20th-21st Century Techniques	6
57-257	Orchestration I	6
57-xxx	Music Support Course	6
57-189	Introduction to Repertoire and Listening for Musicians	3
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-181	Solfege I	3
57-182	Solfege II	3
57-183	Solfege III	3
57-184	Solfege IV	3

57-161	Eurhythmics I	3
57-162	Eurhythmics II	3
57-173	Survey of Western Music History	9

Music and Technology Core 120 units

15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10
15-322	Introduction to Computer Music	9
18-100	Introduction to Electrical and Computer Engineering	12
18-202	Mathematical Foundations of Electrical Engineering	12
18-290	Signals and Systems	12
57-101	Introduction to Music Technology	6
57-347	Electronic and Computer Music	6
57-337	Sound Recording	6
57-338	Sound Editing and Mastering	6
57-438	Multitrack Recording	9
57-571	Music and Technology Project	12
57-572	Music and Technology Project	12

Concentration

Students complete either the Music Concentration or the Technical Concentration:

Music Concentration	60 units
57-5xx	Studio (4 semesters) 36
57-4xx	Major Ensemble (4 semesters) 24

Technical Concentration	57 or 55 units
21-127	Concepts of Mathematics 10
15/18-213	Introduction to Computer Systems 12

AND EITHER:

18-220	Electronic Devices and Analog Circuits 12
18-240	Structure and Design of Digital Systems 12
15-2xx/18-3xx	Electives in ECE or CS 12
or above	

OR:

15-128	Freshman Immigration Course 1
15-210	Parallel and Sequential Data Structures and Algorithms 12
15-323	Computer Music Systems and Information Processing 9
15-2xx/18-3xx	Electives in ECE or CS 12
or above	

Total number of units required for major 380

Minor in Collaborative Piano for Piano Majors in the School of Music

Admission Requirements:

The student must apply to enter the program in the office of the Director of Student Services (CFA 108).

36 units Required Courses

57-381	Collaborative Piano I	6
57-382	Collaborative Piano II	6
57-383	Collaborative Piano III	6
57-384	Collaborative Piano IV	6
57-385	Collaborative Piano V	6
57-386	Collaborative Piano VI	6

18 units Electives

(choose from the following courses)

57-220	English Diction	3
57-221	Italian Diction	3
57-222	French Diction	3
57-223	German Diction	3
57-332	Introduction to Conducting	6
57-336	Instrumental/Choral Conducting	6
57-431	Italian Literature and Repertoire	3
57-432	French Literature and Repertoire	3
57-433	Musical Theatre Literature and Repertoire	3
57-434	Musical Theatre Literature and Repertoire	3
57-435	German Literature and Repertoire	3
57-436	English/Contemporary Literature and Repertoire	3
57-459	Score Reading/Keyboard Harmony	6
57-607	Vocal Methods	3

Minimum units required for Collaborative Piano Minor: 54

Minor in Conducting for Students in the School of Music

Admission Requirements:

1. The student must apply to enter the program in the office of the Director of Student Services (CFA 108) and have an interview with a member of the conducting faculty.
2. A 3.0 cumulative overall QPA and good academic standing are required for acceptance into the minor in conducting. Note that only a limited number of students can be accepted into the program.
3. In addition to the prerequisite courses listed below, the student must display superior solfège skills, by completing Advanced Solfège I and II with "A" or "B" grades or by demonstrating the equivalent level of skills.
4. Introduction to Conducting and Instrumental/Choral Conducting must be completed during the sophomore year with "A" grades before the student can register for the advanced conducting courses.
5. Conducting Practicum must be taken during the same semester as Independent Study in Conducting.
6. A 3.0 cumulative overall QPA is required for graduation with the minor in conducting.

30 units Prerequisite Courses

57-152	Harmony I	9
57-153	Harmony II	9
57-161	Eurhythmics I	3
57-162	Eurhythmics II	3
57-189	Introduction to Repertoire and Listening for Musicians	3
57-191	Keyboard Studies	3

45 units Required Courses

57-332	Introduction to Conducting	6
57-336	Instrumental/Choral Conducting	6
57-408	Form and Analysis	6
57-257	Orchestration I	6
57-459	Score Reading/Keyboard Harmony	6
57-xxx	Music Support Course	6
57-364	Conducting Practicum	3
57-618	Independent Study in Conducting	6

12 units Electives

(choose from the following courses)

57-220	English Diction	3
57-221	Italian Diction	3
57-222	French Diction	3
57-223	German Diction	3
57-258	20th-21st Century Techniques	6
57-337	Sound Recording	6

57-338	Sound Editing and Mastering	6
57-360	Brass Methods	3
57-361	Percussion Methods	3
57-363	String Methods	3
57-362	Woodwind Methods	3
57-431	Italian Literature and Repertoire	3
57-432	French Literature and Repertoire	3
57-435	German Literature and Repertoire	3
57-607	Vocal Methods	3
57-227	Jazz Orchestra	3
57-229	Chamber Music	3
Minimum units required for Conducting minor:		57

Minor in Music Education for Students in the School of Music

Admission Requirements:

The student should apply to the music education faculty no earlier than spring of the freshman year.

45 units Corequisite General Courses

76-101	Interpretation and Argument	9
21-xxx	Mathematics Course #1	9
21-xxx	Mathematics Course #2	9
76-xxx	English Literature Course	9
85-xxx	Educational Psychology Course	9

18 units Corequisite Music Courses

57-391	Keyboard Studies (Music Ed)	3
57-392	Keyboard Studies (Music Ed)	3
57-393	Keyboard Studies Test (Music Ed)	0
57-332	Introduction to Conducting	6
57-336	Instrumental/Choral Conducting	6

General Education Courses

36 units

Also required are three classes offered at other Pittsburgh schools: EDUC 333 Assessment & Adaptation: Students with Special Needs AND EDUC 634 Inclusion: Issues and Strategies, both at Chatham University; and IL 2257 Teaching English Language Learners, at the University of Pittsburgh (27 units).

57-331	Principles of Education	9
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48 units Music Education Methods Courses

General Methods Courses

57-375	Music in the Elementary School	6
57-356	Elementary Guided Teaching	3
57-376	Music in the Secondary School	6
57-355	Secondary Guided Teaching	3

Applied Area Methods Courses

57-207	Secondary Studio	Var.
57-360	Brass Methods	3
57-361	Percussion Methods	3
57-363	String Methods	3
57-362	Woodwind Methods	3
57-607	Vocal Methods	3

Band Methods Courses

Required is either Fundamentals of Marching Band or Stage Direction.

57-334	Fundamentals of Marching Band	3
57-370	Stage Direction	3
57-333	Band and Choral Arranging	6

15 units Music Education Teaching Courses

57-608	Observation	3
57-603	Practice Teaching (Elementary)	6

57-604	Practice Teaching (Secondary)	6
Minimum units required for Music Education Minor:		99

Minor in Music Technology for Students in the School of Music

Admission Requirements:

The student must apply to enter the program in the office of the Director of Student Services (CFA 108).

18 units Prerequisite Courses

57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfege I	3
57-189	Introduction to Repertoire and Listening for Musicians	3

21 units Sound Recording Courses

57-337	Sound Recording	6
57-338	Sound Editing and Mastering	6
57-438	Multitrack Recording	9

21 units Music Technology/Sound Courses (Choose 3)

Choose three courses. One of the three courses must be either Introduction to Computer Music or Electronic and Computer Music. (Note that 15-112 is a prerequisite for 15-322; 57-101 or 57-171 is a prerequisite for 57-347.) Other courses may be taken with the permission of the music technology minor advisor.

15-322	Introduction to Computer Music	9
15-323	Computer Music Systems and Information Processing	9
33-114	Physics of Musical Sound	9
54-509	Theatrical Sound System Design	9
54-666	Production Audio	6
57-345	Hacking the Music World	9
57-347	Electronic and Computer Music	6
60-131	3D Media Studio II	5
60-210	Electronic Media Studio: Introduction to Interactivity	10

Minimum units required: 67

Minor in Music Theory for Students in the School of Music

Admission Requirements:

The student must apply to enter the program in the office of the Director of Student Services (CFA 108).

18 units Prerequisite Courses

57-152	Harmony I	9
57-161	Eurhythmics I	3
57-181	Solfege I	3
57-189	Introduction to Repertoire and Listening for Musicians	3

21 units Upper Level Theory Courses (Choose 3)

See theory courses on the Music Support Courses Two-Year Rotation list. It is available on the Inside Music website (<http://music.cfa.cmu.edu>). A graduate course may be taken with the permission of the instructor.

Graduate Theory Course (Choose 1)

units 6-9

See graduate theory courses on the Music Support Courses Two-Year Rotation list. It is available on the Inside Music website (<http://music.cfa.cmu.edu>). The course is to be chosen with the advisor's approval.

18 units Support Courses

33-114	Physics of Musical Sound	9
57-377	Psychology of Music	9
Minimum units required for Music Theory Minor:		70

Minor in Sound Design – IDEaTe

The minor in Sound Design is offered by the School of Music as part of the Integrative Design, Arts and Technology (IDEaTe) network. IDEaTe offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students will engage in active “learning by doing” in state-of-the-art maker spaces. The program addresses current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDEaTe undergraduate curriculum consists of eight interrelated concentration areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and arts: Game Design, Animation & Special Effects, Media Design, Learning Media, Sound Design, Innovation and Entrepreneurship, Intelligent Environments, and Physical Computing. For more information about the IDEaTe network, please visit <http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#ideate>

In the Sound Design minor, students create experimental music or explore new, technology-enabled applications and markets for sound design, music creation, and performance.

Curriculum

Required Courses

- One Portal Course
 - 18-090 Digital Media Interactions: Signal Processing for the Arts
 - 62-150 Introduction to Media Synthesis and Analysis for students in the College of Engineering, Mellon College of Science, and School of Computer Science.
- Four Collaborative or Supportive Courses
 - 57-344 Experimental Sound Systems and Synthesis
 - 57-345 Hacking the Music World
 - 15-322 Introduction to Computer Music
 - 54-367 Conceptual Sound Design
 - 57-347 Electronic and Computer Music
 - 60-439 Hybrid Instrument Building
 - 54-509 Theatrical Sound System Design

Electives

Students may take a collaborative or supportive course from one of the other IDEaTe areas as one of their four collaborative or supportive courses toward the Sound Design minor.

Double-Counting Restriction

Students may double-count two of their Sound Design minor courses for other requirements.

Minor in Music Performance/Music (Composition) for Students in the School of Music

Admission Requirements:

1. The student must apply to enter the program in the office of the Director of Student Services (CFA 108).
2. The student must perform an acceptable audition. Requirements for the audition can be found in the Admission section of the Undergraduate Catalog.

18 units Prerequisite Courses

57-161	Eurhythmics I	3
57-181	Solfège I	3
57-152	Harmony I	9
57-189	Introduction to Repertoire and Listening for Musicians	3

24 units Required Studio Courses (studio fee is charged)

57-496	Minor Studio	6
57-497	Minor Studio	6
57-498	Minor Studio	6
57-499	Minor Studio	6

18 units Required Language Courses (voice minors)

Language Course (Choose 1)

82-101	Elementary French I	12
82-121	Elementary German I	12
82-161	Elementary Italian I	12

Diction Course (Choose 1)

An introductory course in the applicable language is a corequisite for each of these courses.

57-221	Italian Diction	3
57-222	French Diction	3
57-223	German Diction	3

Literature and Repertoire Course (Choose 1)

An introductory course in the applicable language is a prerequisite for each of these courses.

57-431	Italian Literature and Repertoire	3
57-432	French Literature and Repertoire	3
57-435	German Literature and Repertoire	3

Minimum Units Required for Music Performance/Music (Composition) Minor: 24-42

Faculty

DOUGLAS AHLSTEDT, Professor of Voice – M.M., Eastman School of Music; Carnegie Mellon, 1998–.

CHRISTOPHER ALLEN, Artist Lecturer in Percussion.

ALBERTO ALMARZA, Associate Professor of Flute – M.F.A., Carnegie Mellon University; Carnegie Mellon, 1991–.

DONNA AMATO, Artist Lecturer in Piano and Staff Pianist – B.M., University of Arizona; Carnegie Mellon, 1998–.

JENNIFER AYLMEYER, Assistant Professor of Voice.

LEONARDO BALADA, University Professor of Composition – Diploma, The Juilliard School of Music; Carnegie Mellon, 1970–.

JEANNE BAXTRESSER, Vira I. Heinz University Professor of Flute – B.M., The Juilliard School of Music; Carnegie Mellon, 1997–.

NEAL BERNTSEN, Artist Lecturer in Trumpet – M.M., Northwestern University; Carnegie Mellon, 2003–.

RAYMOND BLACKWELL, Vocal Coach and Staff Pianist – M.M., SUNY Binghamton; Carnegie Mellon, 2003–.

JEREMY BRANSON, Artist Lecturer in Percussion Carnegie Mellon, 2009–.

WILLIAM CABALLERO, Associate Teaching Professor in Horn – B.M., New England Conservatory; Carnegie Mellon, 2007–.

JUDITH CAGLEY, Artist Lecturer in Solfège – M.S.Ed., Duquesne University; Carnegie Mellon, 2006–.

CHRISTOPHER CAPIZZI, Artist Lecturer in Jazz Piano – M.A.M., Carnegie Mellon University; Carnegie Mellon, 2004–.

ANDRES CARDENES, Dorothy Richard Starling and Alexander Speyer, Jr. University Professor of Violin Carnegie Mellon, 1989–.

ANDREW CARLISLE, Director of Piping.

L. MARK CARVER, Associate Teaching Professor in Collaborative Piano – M.M., Carnegie Mellon University; Carnegie Mellon, 1995–.

REBECCA CHERIAN, Artist Lecturer in Trombone Carnegie Mellon, 1993–.

ALEC CHIEN, Artist Lecturer in Piano Literature and Repertoire.

DENIS COLWELL, Head and Associate Professor Carnegie Mellon, 1980–.

MURRAY CREWE, Artist Lecturer in Bass Trombone Carnegie Mellon, 2001–.

DANIEL CURTIS, Resident Conductor.

- MICHELE DE LA REZA, Assistant Teaching Professor of Dance – M.S., University of Pittsburgh; Carnegie Mellon, 2007–.
- CYNTHIA DEALMEIDA, Associate Teaching Professor in Oboe – M.M., Temple University; Carnegie Mellon, 1991–.
- ERIC DEFADE, Director of Jazz EnsembleCarnegie Mellon, 2002–.
- ROBERT DELL, Artist Lecturer in Music Education.
- MARK DOMENCIC, Artist Lecturer in Music Theory – M.M., Carnegie Mellon University; Carnegie Mellon, 2007–.
- THOMAS DOUGLAS, Teaching Professor of Voice – M.M., Duquesne University; Carnegie Mellon, 1991–.
- PAUL EVANS, Artist Lecturer in Percussion – MM, Temple University; Carnegie Mellon, 1995–.
- ROBERT FALLON, Assistant Professor of Musicology – Ph.D., University of California, Berkeley; Carnegie Mellon, 2009–.
- JAMES FERLA, Artist Lecturer in Guitar – M.F.A., Carnegie Mellon University; Carnegie Mellon, 1977–.
- CYRUS FOROUGH, Professor of ViolinCarnegie Mellon, 2001–.
- NANCY GALBRAITH, Professor of Composition – M.M., West Virginia University; Carnegie Mellon, 1984–.
- PAUL GERLACH, Artist Lecturer in Music Education – M.F.A., Carnegie Mellon University; Carnegie Mellon, 1982–.
- NANCY GOERES, Artist Lecturer in Bassoon – B.M., Boston University; Carnegie Mellon, 1988–.
- PETER GUILD, Artist Lecturer in Double Bass.
- DAVID HARDING, Associate Professor in Viola and Chamber Music.
- MICAH HOWARD, Artist Lecturer in Double BassCarnegie Mellon, 2010–.
- ROSEANNA IRWIN, Associate Teaching Professor of Coaching and Accompanying – M.M., Duquesne University; Carnegie Mellon, 1990–.
- JOHN PAUL ITO, Assistant Professor of Music TheoryCarnegie Mellon, 2011–.
- ANNE JACKOVIC, Artist Lecturer in Solfege.
- CURTIS JOHNSON, Artist Lecturer in Saxophone.
- PAUL JOHNSTON, Artist Lecturer in Music HistoryCarnegie Mellon, 2005–.
- ANNABELLE JOSEPH, Professor of Music – D.A., Carnegie Mellon University; Carnegie Mellon, 1986–.
- KENNETH KEELING, Associate Head and Professor Emeritus of Music – D.M.A., Catholic University of America; Carnegie Mellon, 1996–.
- SUNG-IM KIM, Staff PianistCarnegie Mellon, 2011–.
- CRAIG KNOX, Artist Lecturer in TubaCarnegie Mellon, 2005–.
- PETER KOPE, Assistant Teaching Professor of DanceCarnegie Mellon, 2007–.
- STEPHEN KOSTYNIK, Artist Lecturer in French Horn.
- CARLA LARocca, Associate Teaching Professor of Keyboard Studies – M.F.A., Carnegie Mellon University; Carnegie Mellon, 1991–.
- LANCE LADUKE, Artist Lecturer in Euphonium – B.M., Michigan State University; Carnegie Mellon, 2003–.
- ELIZABETH LAWRENCE, Artist Lecturer in Jazz Voice and Director of Jazz Vocal Ensemble – M.M., Manhattan School of Music; Carnegie Mellon, 1996–.
- GREGORY LEHANE, Professor of Drama and Music – M.F.A., Carnegie Mellon University; Carnegie Mellon, 1991–.
- HANNA WU LI, Professor of Piano and Piano Pedagogy – M.M., Northwestern University; Carnegie Mellon, 1969–.
- LUZ MANRIQUEZ, Associate Teaching Professor in Collaborative Piano – M.M., Carnegie Mellon University; Carnegie Mellon, 1992–.
- JOHN MARCINIZYN, Artist Lecturer in Guitar and Composition – Ph.D., University of Pittsburgh; Carnegie Mellon, 1991–.
- JOHN MCCARTHY, String Methods Instructor.
- LORNA MCGHEE, Artist Lecturer in FluteCarnegie Mellon, 2015–.
- MONIQUE MEAD, Director of Music Entrepreneurial Studies.
- STEPHEN NEELY, Artist Lecturer in Eurhythmics – M.M., Carnegie Mellon University; Carnegie Mellon, 1998–.
- RODRIGO OJEDA, Staff PianistCarnegie Mellon, 2011–.
- BENJAMIN OPIE, Artist Lecturer in Music Technology – M.M., Duquesne University; Carnegie Mellon, 2005–.
- NATALIE OZEAS, Professor of Music Education and Director of Graduate Studies – Ed.D., University of Pittsburgh; Carnegie Mellon, 1989–.
- ROBERT PAGE, University Professor Emeritus of Music – M.M., Indiana University; Carnegie Mellon, 1976–.
- MILDRED MILLER POSVAR, Artist Lecturer in Voice – BM, Cleveland Institute of Music; Carnegie Mellon, 1981–.
- DAVID PREMO, Artist Lecturer in CelloCarnegie Mellon, 1994–.
- RICHARD RANDALL, Assistant Professor of Music Theory – Ph.D., Eastman School of Music; Carnegie Mellon, 2008–.
- MICHAEL RUSINEK, Artist Lecturer in ClarinetCarnegie Mellon, 1998–.
- CHRISTOPHER RUTH, Artist Lecturer in Music History.
- VAHAN SARGSYAN, Staff Pianist.
- SERGEY SCHEPKIN, Associate Professor of Piano – D.M.A., New England Conservatory; Carnegie Mellon, 2003–.
- STEPHEN SCHULTZ, Associate Teaching Professor of Music History and Flute – M.M., San Francisco State University; Carnegie Mellon, 2002–.
- RICCARDO SCHULZ, Associate Teaching Professor and Director of Recording Activities – M.A., University of Pittsburgh; Carnegie Mellon, 1988–.
- FRANCO SCIANNAMEO, Associate Teaching Professor of Film Musicology and CFA Associate Dean.
- MARIA SPACAGNA, Associate Professor of Voice.
- STEPHEN STORY, Associate Conductor of Wind Ensemble.
- PETER SULLIVAN, Artist Lecturer in TromboneCarnegie Mellon, 2000–.
- DANIEL TEADT, Artist Lecturer in Voice.
- MARILYN TAFT THOMAS, Professor of Music – Ph.D., University of Pittsburgh; Carnegie Mellon, 1981–.
- THOMAS THOMPSON, Associate Teaching Professor of Clarinet and Co-Director of Wind Ensemble – M.M., Northwestern University; Carnegie Mellon, 1986–.
- KELLY TRUMBULL, Artist Lecturer in ActingCarnegie Mellon, 2015–.
- REZA VALI, Professor of Composition – Ph.D., University of Pittsburgh; Carnegie Mellon, 1988–.
- GRETCHEN VAN HOESEN, Artist Lecturer in Harp – M.M., The Juilliard School; Carnegie Mellon, 1985–.
- KAREN ROETHLISBERGER VERM, Staff Pianist – M.M., Cincinnati Conservatory; Carnegie Mellon, 2004–.
- GEORGE VOSBURGH, Artist Lecturer in Trumpet and Co-Director of Wind Ensemble – B.A., University of Rochester; Carnegie Mellon, 2003–.
- JAMES WHIPPLE, Artist Lecturer in Music Theory – BA, Carnegie Mellon University; Carnegie Mellon, 1995–.
- COLETTE JOUSSE WILKINS, Artist Lecturer in Solfege – First Prize, Conservatoire National de Versailles, France; Carnegie Mellon, 1974–.
- ANNE MARTINDALE WILLIAMS, Artist Lecturer in Cello – Diploma, Curtis Institute of Music; Carnegie Mellon, 1987–.
- CHRISTOPHER WU, Artist Lecturer in ViolinCarnegie Mellon, 2009–.
- LENNY YOUNG, Artist Lecturer in SolfegeCarnegie Mellon, 2015–.
- ISAIAS ZELKOWICZ, Artist Lecturer in Viola – M.M., The Juilliard School; Carnegie Mellon, 1981–.

The Marianna Brown Dietrich College of Humanities and Social Sciences

Richard Scheines, Dean
 Brian Junker, Associate Dean for Academic Affairs
 Joseph E. Devine, Associate Dean for Undergraduate Studies and Interim Director, Dietrich College Academic Advisory Center
<http://www.hss.cmu.edu>

The Dietrich College of Humanities and Social Sciences is one of Carnegie Mellon's seven principal colleges. The college consists of the undergraduate program in Economics; the departments of English, History, Modern Languages, Philosophy, Psychology, Social and Decision Sciences, and Statistics; an interdepartmental program in Information Systems; and the Institute for Politics and Strategy. The college accounts for approximately one-fifth of the university's undergraduate population; 80% of the college's students are undergraduates. The college is staffed by 223 full-time faculty, and approximately 20 part-time faculty.

Like its Carnegie Mellon counterparts in engineering, science, computer science, business, and the fine arts, the college has three primary and interrelated foci: undergraduate education, graduate education, and research or creative pursuits. Thus, the college shares in the university's mission of merging first-rate, innovative research and creativity with undergraduate and graduate education.

Liberal/Professional Education

Edward Fiske, former Education Editor of The New York Times and author of the Fiske Guide to Colleges, long ago noted that the college and university have done "perhaps the most original thinking of any American university in pursuing the twin goals of liberal-professional education." These goals continue to guide the college's educational enterprise. The college's educational program is "liberal" in that it stresses breadth and invites wide-ranging inquiry, both through its general education curriculum and through programs in the humanities, behavioral sciences, and social sciences. The "professional" dimension of the college's educational program derives from practical application of analytical and problem-solving skills and also from a subset of in-depth major programs which prepare students for a range of career fields as well as for graduate or professional school. In its belief that these two types of knowledge ("liberal" and "professional") are highly complementary, Dietrich College embraces a philosophy that has its roots in Carnegie Mellon's institutional origins: namely, that the traditional liberal arts disciplines merit close, rigorous study, while at the same time practical skills are also mastered.

The rationale for this liberal/professional approach stems from the premise that the intellectual foundations of a challenging liberal education and meaningful professional education are essentially the same. Knowledgeable and effective citizens are as much in need of broad intellectual perspectives, analytical skills, and problem-solving strategies as are most professionals. Moreover, as leaders in American higher education generally agree, undergraduate education is not well served if professional specialization in undergraduate programs is achieved prematurely. The challenge is to strike a balance between breadth and depth, both within and outside of one's specialty. Such a balance insures versatility in one's profession and the knowledge and ability to keep pace as individuals and citizens with changes in our social, technical, and cultural environments. Thus, the objectives of both liberal and professional education can and should work in tandem to complement and enhance one another.

Degree and Program Options

Dietrich College offers a wide range of majors, as well as minors which provide a secondary focus to one's primary area of study. In addition, there are a number of special programs which add breadth and enhance a student's overall experience.

Dietrich College Majors

Department	Name of Major (Degree Options)
Economics	Economics (B.A./B.S.)
English	English (B.A.)
English	Creative Writing (B.A.)
English	Professional Writing (B.A.)
English	Technical Writing and Communication (B.S.)
History	Global Studies (B.A.)
History	Social and Political History (B.A./B.S.)
Interdepartmental*	Economics and Mathematical Sciences (B.S.) (by admission)
Interdepartmental	Economics and Statistics (B.S.)
Interdepartmental	Environmental Policy (additional major only)
Interdepartmental	Ethics, History, and Public Policy (B.A./B.S.)
Interdepartmental	Information Systems (B.S.) (by admission)
Interdepartmental	Linguistics (B.A.)
Interdepartmental**	Neuroscience (B.S.)
Interdepartmental***	Psychology and Biological Sciences (B.S.)
Interdepartmental+	Statistics and Machine Learning (B.S.)
Interdepartmental	Student-Defined (B.A./B.S.) (by admission)
Modern Languages	Chinese Studies (B.A.)
Modern Languages	French and Francophone Studies (B.A.)
Modern Languages	German Studies (B.A.)
Modern Languages	Hispanic Studies (B.A.)
Modern Languages	Japanese Studies (B.A.)
Modern Languages	Russian Studies (B.A.)
Philosophy	Logic and Computation (B.S.)
Philosophy	Philosophy (B.A.)
Institute for Politics and Strategy	International Relations and Politics (B.S.)
Psychology	Cognitive Science (B.S.)
Psychology	Psychology (B.A./B.S.)
Social and Decision Sciences	Decision Science (B.S.)
Social and Decision Sciences	Policy and Management (B.S.)
Statistics	Statistics (B.S.)

Notes:

* Offered jointly by the Program in Economics and the Department of Mathematical Sciences

** Offered jointly by the Department of Biological Sciences and the Center for the Neural Basis of Cognition

*** Offered jointly by the Departments of Psychology and Biological Sciences

+ Offered jointly by the Departments of Statistics and Computer Science

Additional Majors

Dietrich College students may pursue additional majors and/or minors in the college, as well as in other Carnegie Mellon colleges. An additional major refers to the completion of the requirements for a second major while also completing the requirements for the primary major and degree.

Most Dietrich College majors are also available as additional majors; one (Environmental Policy) is available only as an additional major. Students from outside Dietrich College can pursue additional majors offered by the college, and would be required to complete only those courses in the college's general education program that are prerequisites to courses required for the Dietrich College major in question.

Minors

Minors are like majors in that they consist of coherent programs of study in a department, or across departments. Minors differ from majors in the number of the courses required and in the breadth and depth of the curriculum in the minor's area(s) of study. Dietrich College students can also pursue minors offered and made available by other Carnegie Mellon colleges and departments.

There are two types of minors in Dietrich College: departmental minors, which are housed in a single Dietrich College academic department; and interdepartmental minors, which are sponsored by more than one academic department and administered through the faculty advisor's academic department. The college's minors are available to students from all colleges in the university.

Department	Name of Minor
Economics	Economics
English	Creative Writing
English	English
English	Professional Writing
English	Technical Writing
History	Anthropology
History	Social and Political History
Interdepartmental	African and African American Studies
Interdepartmental	Environmental Studies
Interdepartmental	Film and Media Studies
Interdepartmental	Gender Studies
Interdepartmental	Global Systems and Management
Interdepartmental	Health Care Policy and Management
Interdepartmental	Linguistics
Interdepartmental	Neural Computation
Interdepartmental	Religious Studies
Interdepartmental	Science, Technology and Society
Interdepartmental	Sociology
Interdepartmental	Student-Defined (by admission)
Modern Languages	Chinese Studies
Modern Languages	French and Francophone Studies
Modern Languages	German Studies
Modern Languages	Hispanic Studies
Modern Languages	Japanese Studies
Modern Languages	Russian Studies
Philosophy	Ethics
Philosophy	Logic and Computation
Philosophy	Philosophy
Institute for Politics and Strategy	International Relations and Politics
Institute for Politics and Strategy	Politics and Public Policy
Psychology	Cognitive Neuroscience
Psychology	Psychology
Social and Decision Sciences	Policy and Management
Statistics	Statistics

Multiple Degrees

"Multiple undergraduate degrees" is defined as more than one undergraduate degree granted by the university (whether simultaneous or sequential). One diploma is awarded for each degree; each degree has one

primary major associated with it, and the possibility of an additional major and/or minor.

Dietrich College undergraduate students who wish to earn an additional undergraduate degree with a primary major also from Dietrich College must:

- Satisfy all requirements for the primary major to be linked to the additional degree.
- Complete at least 90 units beyond the total units required for the first degree. If the major associated with the additional degree requires less than 90 units, the student would earn additional elective units to reach the 90-unit minimum. If the major associated with the additional degree requires more than 90 units, the student would perform exceed the 90-unit minimum in order to fulfill all of the requirements for the additional degree's primary major.
- Comply with CMU's Statute of Limitations Policy: All units required for an undergraduate degree, whether earned in residence, transferred from another institution or granted via advanced placement, must have been earned within eight (8) years prior to the date on which the degree is granted.

Non-Dietrich College undergraduate students at Carnegie Mellon who wish to earn an additional undergraduate degree with a Dietrich College primary major must complete all of the requirements listed above, plus any portion of the Dietrich College general education program not already fulfilled by prior undergraduate course work.

Bachelor of Arts & Bachelor of Science

Some Dietrich College majors lead to a Bachelor of Arts (B.A.) degree and others lead to a Bachelor of Science (B.S.) degree. In some majors students may choose between a B.A. and a B.S. degree. B.A. degree programs usually require less course work in technical and/or quantitative disciplines, and more depth and breadth in various humanities, social sciences, and (in some cases) the arts. In contrast, B.S. degrees are offered in majors requiring more technical, quantitative or scientific competencies.

Dietrich College General Education Program

<http://www.hss.cmu.edu/gened/>

Carnegie Mellon's educational legacy emphasizes the connection between theoretical and practical knowledge. Similarly, the university's interdisciplinary approach to education embraces the practical application and analysis of knowledge in institutional, social, historical, and global contexts. The Dietrich College general education program (hereafter referred to as the "GenEd program") supports the development of that expertise and ensures that students gain well-informed perspectives and methodologies by providing the foundational knowledge required for in-depth study. Additionally, the GenEd program provides freshmen and sophomores - whether they have a specific interest, multiple interests, or are undecided about majors - with a systematic, intentional way of sampling the many options available in order to formulate, pursue and achieve their academic goals.

Categories

To transcend narrow disciplinary boundaries, the GenEd program focuses on five broad intellectual activities that are exercised in nearly all disciplines: communicating, reflecting, modeling, deciding and creating. General subject areas associated with each activity are also indicated below. These activities form the bases for GenEd curriculum categories, in which suitable courses are included from all parts of the university.

The five categories are:

1. communicating (<http://www.hss.cmu.edu/gened/gened-category.asp#Communicating>): language and interpretation
2. reflecting (<http://www.hss.cmu.edu/gened/gened-category.asp#Reflecting>): societies and cultures
3. modeling (<http://www.hss.cmu.edu/gened/gened-category.asp#Modeling>): mathematics, the physical and natural sciences, and experiments
4. deciding (<http://www.hss.cmu.edu/gened/gened-category.asp#Deciding>): social sciences and values
5. creating (<http://www.hss.cmu.edu/gened/gened-category.asp#Creating>): designs and productions

This framework highlights central features of an ideal learning environment and the university's core intellectual mission.

Courses

1. Communicating: Language and Interpretations(18 units)

Courses in this category give special attention to the study of language as interpretation, expression and argument within and across multiple discourses. Students examine language for its internal logics and structures. They also explore its rhetorical, historical, cultural, or philosophical dimensions, assessing how it functions while expanding their writing skills and sharpening their analytical abilities.

Required	Units
76-101 Interpretation and Argument	9
xx-xxx One additional "communicating" course*	9

Note: Non-native English speakers may be placed into 76-100 Reading and Writing in an Academic Context (9 units), instead of 76-101, in their first semester. After successful completion of 76-100, they must take 76-101. For these students, these two courses will fulfill the GenEd "communicating" requirement category.

* For a list and descriptions of additional courses approved for this category, visit the Dietrich College General Education web site (<http://www.hss.cmu.edu/gened>)

2. Reflecting: Societies and Cultures(18 units)

This category emphasizes the study of history, society, and culture from local and global perspectives. Courses investigate contemporary societies as well as those of the past, along with their rich array of cultural products, artifacts, and ideas. They encourage a comparative and reflective approach to the understanding of the past and what it can bring to the constitution of present social relations and cultural outlooks.

Required	Units
79-104 Global Histories	9
xx-xxx One additional "reflecting" course*	9

* For a list and descriptions of additional courses approved for this category, visit the Dietrich College General Education web site (<http://www.hss.cmu.edu/gened>).

3. Modeling: Mathematics, Physical and Natural Sciences, and Experiments(27 units)

Courses in this category stress the interplay of mathematical (formal) theories and experimental work. Some courses investigate the internal structure of theories, whereas others use them as models for producing real-world knowledge. Such models may be drawn from a variety of disciplines including the natural and mathematical sciences, but also such fields as psychology and computer science. The interactions between theorizing and experimenting (observing) can be understood within an intellectual framework that invites comparative assessment.

- mathematical sciences (complete a minimum of 9 units)
- natural sciences (complete a minimum of 9 units)
- one other modeling course (complete a minimum of 9 units)

(For courses approved for this category, visit the Dietrich College General Education (<http://www.hss.cmu.edu/gened>) web site.)

4. Deciding: Social Sciences and Values(18 units)

The theme of this category is the exploration of cognitive, behavioral and ethical dimensions of decision-making on both the individual and societal levels. Making decisions requires a broad understanding of human rationality and social interaction. Some courses examine the critical collection and analysis of data for achieving such an understanding, whereas others emphasize the historical development of policies and values which form the matrix for decision-making.

Required	Units
36-201 Statistical Reasoning and Practice	9
xx-xxx One additional "deciding" course*	9

* For a list and descriptions of additional courses approved for this category, visit the Dietrich College General Education web site (<http://www.hss.cmu.edu/gened>).

5. Creating: Designs and Productions(18 units)

In the arts, the humanities, the sciences, and in engineering, it is essential to produce artifacts: e.g., a painting, a poem, a musical performance, a piece of technology, the design of an experiment, or the proof of a mathematical theorem. Courses may center on the students' creation of artifacts, but they may also analyze such creations by exploring creative

processes at work within and across disciplines. Such explorations should be informed by a deep understanding of contexts of production and reception.

For courses approved for this category, visit the Dietrich College General Education (<http://www.hss.cmu.edu/gened>) web site.

6. TWO Additional GenEd courses(18 units)

These courses are selected from any GenEd category.

7. University Requirement (UR)(3 units)

99-101 Computing @ Carnegie Mellon	3
or 99-102 Computing @ Carnegie Mellon	

This course is a 3-unit mini-course, pass/no credit, completed in the first or second semester of the first year.

8. Freshman Seminar Requirement (FSR)(9 units)

This requirement ensures that all first-year students in Dietrich College have at least one small-group course experience in their first year. Taught by selected members of the college's faculty, these seminars enroll 15-17 students, are centered around topics based on faculty research and expertise, and are formatted to encourage a high level of student participation and interaction. For current seminar topics and course descriptions, visit the Dietrich College general education (<http://www.hss.cmu.edu/gened>) website. NOTE: The freshman seminar will not simultaneously fulfill any other requirement (e.g., in a major or minor).

College Services and Programs

The educational programs in Dietrich College are complemented by a number of services, special programs, centers, and computing facilities.

Dietrich College Academic Advisory Center

Joseph E. Devine, Associate Dean and Interim Director
Office: Baker Hall A57
<http://www.cmu.edu/hss/advisory-center/>

The Dietrich College of Humanities and Social Sciences' Academic Advisory Center (AAC) is primarily responsible for advising and monitoring the progress of students prior to deciding on a major. As the "home base" for undergraduates who are new to the college, the AAC provides an accessible, welcoming environment where students can seek information, advice, and counsel about selecting courses, the college's general education program requirements, and the various majors and minors available. Just as important, advisors support students' transition to life and study in the university. The advisor-student relationship is a reciprocal one. Advisors' goals are to meet students where they are, to help them learn to successfully navigate the Carnegie Mellon environment, to become increasingly self-sufficient, and to make viable, informed and confident academic and personal decisions. This kind of relationship is vital to a student's ability to progress, grow and thrive in a new and demanding educational environment. Additionally, the AAC serves as the office of student records for Dietrich College. Acting on behalf of the College Council, the assistant dean oversees adherence to university and college academic policies and procedures, and with staff assistance, processes related transactions.

The center's advising philosophy and strategies, as with academic advising college-wide, reflect the university's statement on academic advising.

The AAC is a walk-in center, although individual appointments may be made and are encouraged. The center's hours are 8:30 a.m. to 5:00 p.m., Monday through Friday.

Globalization and International Politics

Faculty Director (IRP): Kiron K. Skinner, kskinner@andrew.cmu.edu, 412-268-3238, Porter Hall 223F
Faculty Director (GS): John Soluri, jsoluri@andrew.cmu.edu, 412-268-7122, Baker Hall 363
Academic Advisor: Emily Half, ehalf@andrew.cmu.edu, 412-268-7082, Baker Hall A60C
<http://www.cmu.edu/ir/>
<http://www.cmu.edu/hss/globalstudies>

As "globalization" accelerates in and across many domains (politics, economics, trade, culture, the environment, health, etc.), interest in international issues and topics grows steadily. In order to better reflect Carnegie Mellon's comparative strengths in a range of relevant areas, two Dietrich College majors have emerged from a common foundation. One (International Relations and Politics) offers strong conceptual and methodological roots in political science and the other social sciences, while the other (Global Studies) is more squarely grounded in humanities

methodologies and disciplines such as history, anthropology, languages, and cultural studies. Students are thus able to capitalize on the strengths of each major's faculty research and teaching in their respective home departments. Having an academic advisor common to both majors provides a critical linchpin to help students with interests in these fields to see and understand their distinctions. They may then work closely with each program's faculty director for assistance in navigating their way through requirements, vigorously pursuing special opportunities such as a semester in Washington, D.C. or study abroad, and taking part in opportunities for inter-program collaboration.

Dietrich College Senior Honors Program

Joseph E. Devine, Director; Associate Dean for Undergraduate Studies
Office: Baker Hall 154F
<http://www.hss.cmu.edu/>

From its inception in 1982, the Dietrich College senior honors program has provided outstanding undergraduate students with the opportunity to work individually with faculty members throughout the college on original research and creative projects. The honors program is a senior-year program. Admission is based on achievement of a cumulative QPA of at least 3.50 in the major and 3.25 overall, endorsement of a thesis proposal by the faculty member who will serve as thesis advisor, and department head approval. Honors students enroll in an honors thesis course sequence for both semesters of the senior year (9 units per semester). Upon successful completion of the honors thesis, a student qualifies for graduation with Dietrich College Honors, and will have this designation as well as the thesis title noted on the final transcript.

Students have found the honors program to be a very positive experience in allowing for focused, individualized work on a sustained independent project. In the opportunity it provides to demonstrate one's capacity for independent and original work, the senior honors program comprises an experience that helps significantly in presenting oneself to prospective employers or graduate programs.

Humanities Scholars Program

Timothy Haggerty, Director
Office: Baker Hall 154Q
<http://www.hss.cmu.edu/hsp/>

The Humanities Scholars Program (HSP) is a rigorous, four-year undergraduate program dedicated to fostering innovative interdisciplinary study and research in the humanities. The program works with the undergraduate admissions office to identify a subset of students admitted to Dietrich College who have a special interest in the humanities as they are conceptualized at Carnegie Mellon. These students are invited into a program that includes a shared set of courses as well as an optional residential component.

As practiced within its four departments - English, history, philosophy and modern languages - the humanities at Carnegie Mellon provide broad reflective analysis of humanity and its artifacts. Scholarship may incorporate, as examples, hermeneutic, ethnographic, critical, formal, or quantitative analyses within its arguments. At Carnegie Mellon, research has yielded original themes that have become institutional strengths, including social and global perspectives on culture, science and technology; languages, literature and discourse; the arts in society; cognition and rational decision making; and ethics and public policy.

During the first two years of the program, scholars take a series of four seminars that are designed to introduce them to different fields of the humanities and their disciplinary approaches (representative HSP seminars can be viewed on the program website). In the third and fourth years, students are free to pursue their major course of study. The program complements, rather than replaces, a major or minor course of study. In addition, HSP courses help fulfill breadth requirements, including the freshman seminar requirement and selected college general education requirements.

While in the program, scholars also participate in extracurricular events on campus and in the community that include talks by visiting scholars, theater performances, conferences, and exhibits that highlight the importance of humanistic inquiry and its relevance in public discourse.

Students complete their research under the direction of a faculty advisor and meet in a research seminar headed by the director of the program in the spring of their fourth year. This seminar is designed to develop and showcase their abilities in addressing a topic from multiple disciplinary standpoints.

Quantitative Social Science Scholars Program

Russell Golman, Director
Office: Porter Hall 223J
<http://www.cmu.edu/hss/qsss>

The Quantitative Social Science Scholars Program (QSSS) offers a unique opportunity in undergraduate education at Carnegie Mellon. In recent years, advances in computing power, increasingly powerful models of human behavior, and the exponential growth of data sets recording human economic and social activity have created exciting new possibilities for entrepreneurs, policymakers, and scholars seeking insight into human social behavior. Firms throughout the economy can now use data analytics to identify new markets, avoid errors, and improve efficiency. Policymakers can use the same techniques to shape the direction and expand the impact of social policies designed to promote the public good. Social scientists can also use these techniques to create a broader and deeper scientific understanding of human behavior that serves as the foundation upon which both entrepreneurs and policymakers can build.

The QSSS program is designed to help outstanding undergraduates impact society through the use of these techniques. It does so by laying out a structured program of training in advanced quantitative techniques that can be broadly applied across a range of social science disciplines and topics. Students combine this methodological training with more traditional coursework in the social science major of their choice. The program equips students to undertake sophisticated analysis of their own, and features an integrative senior thesis project that applies their methodological training to a research question of their own choosing.

The QSSS program is not a freestanding major or a minor, per se. It is a program designed to be taken in conjunction with a social science major in Dietrich College. The program recruits students with a range of interests across the social sciences to create a cohesive interdisciplinary learning community. Majors that could fit well with this program include (but are not limited to) economics, decision science, policy and management, international relations and politics, and statistics.

Special features of the QSSS program include:

- An optional residential component that allows QSSS students to live together in their first year
- An exclusive QSSS freshman seminar (this seminar fulfills the Dietrich College freshman seminar requirement)
- A core curriculum in five segments: mathematical and statistical foundations, social science modeling, regression analysis of large data sets, data collection and generation, and analytic and computational methods.
- A required senior thesis under the supervision of a faculty advisor from the student's home department and benefitting from the QSSS thesis proseminar.
- A QSSS seminar series that invites speakers to campus to help students in the program see how the skills they are developing are applied both in research and in practice.

Science and Humanities Scholars Program

William Alba, Director
Office: Doherty Hall 2201
<http://www.cmu.edu/shs/>

The Science and Humanities Scholars Program (SHS) is designed to enable talented students to develop and pursue an undergraduate program that builds upon their interests and achievements in the humanities, natural sciences, mathematics, or social sciences. The program is based on a special general education core that provides an academic foundation from which students can select a major in either the Dietrich College of Humanities and Social Sciences or the Mellon College of Science.

Features of the SHS program include:

- Equal access to courses in both MCS and Dietrich College
- An optional residential program that allows a group of SHS first-year students to live together in a dormitory cluster
- Opportunities to collaborate with faculty in cutting-edge interdisciplinary research
- A broad selection of freshman seminars led by distinguished faculty from across the two colleges

Selected students admitted to Dietrich College and/or Mellon College of Science are invited to join the SHS program at the same time that they receive their notification of admission to the university. Those accepting are advised by the SHS program director until they declare a major.

Student-Defined Program

Joseph E. Devine, Director; Associate Dean for Undergraduate Studies
Office: Baker Hall 154

<http://www.cmu.edu/dietrich/undergraduate/student-defined-majors.html>

For students whose educational goals cannot be as adequately served by the curricula of existing programs, the college provides the opportunity to self-define a major or minor. The procedure for establishing such a major

centers on a written proposal, submitted to the college dean's office. This proposal consists of two parts:

Major description and rationale: A description of the components of the proposed program of study; a presentation of the objectives of the program of study, why it represents a coherent and (given available faculty, courses, and other resources) viable course of study, and the reason(s) why these objectives cannot be accomplished within one or more of the college's existing programs.

The curriculum: Presentation of a complete outline of all courses that will comprise the requirements for the major or minor, categorized according to that component of the major program to which each belongs (e.g., mathematics prerequisites; research methods; theoretical perspectives; etc.), and second, a semester-by-semester outline that indicates when each course is to be taken (or, for any already taken, when taken). The minimum requirement for graduation is, as with all majors in the college, 360 units of credit.

Proposals and curricula are evaluated for clarity of focus, coherence and depth in related areas, and viability within the context of the college and university. Proposals should generally be developed no later than the sophomore year, and approved majors begin their program generally no later than the junior year.

As with all other Dietrich College majors, Dietrich College student-defined primary majors must fulfill all of the college's general education requirements.

Study Abroad Scholarships

http://www.hss.cmu.edu/departments/deans_office/studyabroad/scholarships_studyabroad.html

The Dietrich College Dean's Office and the Department of Modern Languages offer the following scholarships to encourage study abroad:

Alumni Study Abroad Scholarships

Funding generously provided by Dietrich College alumni. Multiple scholarships of up to \$1200 are awarded each year to DC, SHS or BHA students to be used toward a semester or full year of study abroad. Current sophomores and juniors will receive preference.

Patricia Askwith-Kenner Scholarships

Provided by an endowment from Patricia Askwith-Kenner. Scholarships of \$3,000 for majors and minors in Modern Languages for semester or full year. Preference to current sophomores and juniors with no study abroad experience.

Patricia Askwith-Kenner Summer Scholarships

Provided by an endowment from Patricia Askwith-Kenner. Scholarships of \$1,200 for majors and minors in Modern Languages for summer study. One scholarship will be reserved for members of the MLSAC. Preference to current sophomores and juniors with no study abroad experience.

The Hannah Estermann Bergman Fund for Study Abroad

Given in memory of Hannah Estermann Bergman, Margaret Morrison Carnegie College class of 1946. This annual scholarship will provide up to \$1,000 to one DC, SHS or BHA student who is currently studying Spanish. Preference will be given to current sophomores and juniors.

The Abel M. Bomberault Travel Fellowship

In memory of Abel M. Bomberault, class of 1956. Multiple scholarships of up to \$3,000 for DC, BHA, or SHS students for semester or full year study abroad in a French-speaking country with preference for France. Majors and minors in French will be given preference.

The Abel M. Bomberault Travel Fellowship (for summer)

In memory of Abel M. Bomberault, class of 1956. Multiple scholarships of up to \$1,200 for DC, BHA, or SHS students for summer study abroad in a French-speaking country with preference for France. Majors and minors in French will be given preference.

The Brona Stein Buerger Scholarship

Given in memory of Brona Stein Buerger, Margaret Morrison Carnegie College class of 1962. These annual scholarships provide up to \$2,000 to one or two DC, BHA or SHS students to be used toward a semester or full year of study abroad. Current sophomores and juniors will receive preference.

Sema (MM'49) and Ivan (E '48) Faigen Scholarship

Made possible by a gift from alumni Sema and Ivan Faigen. Up to \$1500 for majors and minors in Modern Languages for summer study abroad.

The Lena Foo Study Abroad Scholarship

Provided by an Endowment from Lena Foo. Scholarship of \$1,200 for a major or minor in Chinese for summer study in China.

Max Kade Scholarships

Provided by a grant from the Max Kade Foundation. Scholarships of \$1,200 for students of German for summer study at the Goethe Institutes in Germany.

Pickering Scholarships

Made possible by a gift from alumna Martha B. Pickering. Scholarships of \$1,200 for summer study in Asia. Preference to majors/minors in Chinese or Japanese.

Funds from each of these scholarships may be applied to tuition, room and board, airfare to the country and/or book expenses for any accredited study abroad program.

For more information about these scholarships, including eligibility requirements and application time line, see: http://www.hss.cmu.edu/departments/deans_office/studyabroad/scholarships_studyabroad.html

Dietrich College Summer Internship Opportunity Grants

<http://hss.cmu.edu/summerinternoppgrants.html>

Dietrich College encourages students to pursue interesting and professionally relevant internship opportunities as summer employment. Often, however, the very positions that provide students with first-rate, challenging work experiences are unpaid or provide minimal pay. To help compensate students for taking on work experiences that will be invaluable in helping them define and move toward their career goals, the Dietrich College Summer Internship Opportunity Grant Program seeks to make it more possible for students to take advantage of unpaid but worthwhile internship opportunities with grants of up to \$2,000.

Undergraduates (including SHS students) with primary majors in Dietrich College, as well as BHA students are eligible and encouraged to apply. Current sophomores and juniors receive preference. NOTE: Graduating seniors are not eligible.

Students are expected to find their own internships. There are many resources available to help in finding internships, including the Career and Professional Development Center's TartanTrak database. Preference for grants is given to students who find positions in the public sector or non-profit agencies.

For more information, including application time line and instructions, see: <http://hss.cmu.edu/summerinternoppgrants.html>

Carnegie Mellon University Washington Semester Program

Kiron Skinner, Faculty Director; kskinner@andrew.cmu.edu, Porter Hall 223E
Emily Half, Academic Program Manager; ehalf@andrew.cmu.edu;
412-268-7082, Baker Hall A60C

Emily Baddock, Program Director in Washington, DC;
ebaddock@andrew.cmu.edu; 202-608-8316, 100 Maryland Ave NE, Suite
510, Washington, DC 20002

<http://www.cmu.edu/ir/washington-semester-program/index.html>

From embassy headquarters to nongovernmental organizations, think tanks to advocacy organizations, and consulting firms to media outlets, Washington, DC, is a focal point for many international and public policy activities.

Undergraduates from any course of study who would value firsthand policy experience are invited to apply to the Carnegie Mellon University Washington Semester Program (CMU/WSP), sponsored by the university's Institute for Politics and Strategy. As a member of the University of California Washington Center (UCDC) consortium of schools, CMU/WSP is part of a broad and diverse intellectual community of faculty and students. In this semester-long program, students live, work, and study in Washington, DC, coming into direct contact with political, business, and community leaders and learning about the most pressing policy issues of the day.

CMU/WSP students earn 48 units for their semester in Washington, interning three days per week in any sector or field of interest within Washington, DC, while taking classes two days per week and in the evenings. Courses are offered by Carnegie Mellon and UCDC faculty. The Institute for Politics and Strategy sponsors events and a policy forum in Washington for students participating in the program to further enrich their experience and enhance their understanding of how Washington functions as a hub of international and public policy decision making. UCDC also provides policy-oriented events.

Students should contact the academic program manager for more information or to discuss how the CMU/WSP may fit into their curriculum.

Curriculum

All students enroll in the following two courses.

84-360	CMU/WSP: Internship Seminar	12
84-450	IRP Capstone Policy Forum	12

Students select one core seminar from the following list.

Core Seminar

84-330	CMU/WSP: The United States Supreme Court	12
84-331	CMU/WSP: Congress	12
84-332	CMU/WSP: Washington Media	12
84-333	CMU/WSP: General Research Seminar	12
84-334	CMU/WSP: International Policy	12
84-336	CMU/WSP: The Presidency and Executive Branch	12

Students select one elective seminar from the following list.

Elective Seminar

84-340	CMU/WSP: American Political Journalism	12
84-341	CMU/WSP: U.S. Foreign Policy in the Middle East	12
84-342	CMU/WSP: Fiscal Policy-Making in the U.S.	12
84-343	CMU/WSP: Sports, Politics, and Society	12
84-344	CMU/WSP: Politics and Poems: Writing Verse in DC	12
84-345	CMU/WSP: Cultural Policy: Cultural Heritage and Cultural Diplomacy	12
84-346	CMU/WSP: Race and Politics in the American City	12
84-347	CMU/WSP: Lobbying, Money, and Influence in Washington	12
84-348	CMU/WSP: Spies! The Politics of Intelligence	12
84-349	CMU/WSP: The Theater of Politics	12
84-350	CMU/WSP: Campaigns and Elections	12

Academic Standards, Regulations and Protocols

Transferring into Dietrich College

Undergraduate students in other Carnegie Mellon colleges who wish to transfer (<http://www.cmu.edu/hss/advisory-center/transferring/transfer-in.html>) to Dietrich College apply through the college's Academic Advisory Center, located in Baker Hall A57. If approved, the transfer is into the college first and then, when appropriate, into a primary major. Decisions regarding transfer requests will be based on evidence of adequate prior academic performance and on the applicant's prospects for success in the college and intended major.

The earliest point when undergraduates are considered for transfer into Dietrich College is the second semester of the first year. Students interested in transferring to Dietrich College should begin the process well before the course registration period for the upcoming semester. While transfer applications may be submitted at any time, interviews will not be scheduled for transfer candidates during the three-week period that includes course registration week for the next semester and the two weeks prior.

Academic Actions

In order to maintain good academic standing, Dietrich College students must attain at least minimum quality point averages for each semester (as well as cumulatively) and also maintain adequate progress toward completing graduation requirements. Minimum quality point averages for good academic standing are 1.75 in the freshman year and 2.00 thereafter. "Adequate progress towards graduation" generally means that students are successfully completing 45-50 units per semester so that at the end of eight semesters they will have accumulated the minimum of 360 units required for graduation, as well as completed all college Gen Ed and primary major course requirements.

When a student fails to meet minimum performance criteria, it normally results in an "academic action." Depending on the circumstances, one of the following actions is taken: academic probation, continued probation, suspension, or drop. These academic actions are recommended by the college's departments based on the guidelines described below. However, the sequence of the academic actions is not automatic in all cases. Decisions may be based on unique individual student performance and circumstances, and are not determined purely on the basis of grades and quality point averages.

Probation

A student is placed on academic probation when performance either for the semester or cumulatively fails to meet the minimum standard. The term of academic probation is one semester, and signifies to the student the college's insistence that academic performance return to at least the minimum acceptable level. A student is removed from academic probation and returned to good academic standing when both the semester and cumulative quality point averages meet at least the stated minimum, and when adequate progress toward completing graduation requirements is being made. A student who has had one semester on probation and is not yet meeting minimum requirements but is making significant progress in this regard may be continued on probation.

Suspension

Academic suspension is the usual action taken when a student fails to meet the minimum semester or cumulative requirements for two consecutive semesters. In general, a freshman will be suspended if the semester and overall QPAs are below 1.75; for sophomores, juniors, and seniors, if these are below 2.00. Failure to maintain adequate progress toward graduation may also be a contributing factor in such decisions.

The minimum period of academic suspension is normally two semesters, during which a student on academic suspension is expected to reflect on the circumstances leading up to the suspension, identify the issues that prevented him or her from achieving academic success, and take actions that address these issues and demonstrate sufficient readiness to return to the university and successfully resume his or her studies. These actions could include a work or internship experience, a limited amount of approved academic course work at another college or university, and — if relevant — appropriate medical care.

Midway through the semester before a suspended student is eligible to return to the university, he or she will be notified by the Assistant Dean with detailed instructions about the process for requesting approval to return and re-enroll.

Once cleared to return from academic suspension, the Enrollment Services office will be notified and the student will be eligible to enroll. While on academic suspension, students are considered to be on a mandatory "leave of absence," and are governed by college and university policies concerning leaves of absence and withdrawals. See subsequent discussions of "Leave of Absence and Withdrawal from the College." Students returning from academic suspension do so on final academic probation.

Drop

The most severe academic action occurs when a student is dropped from the college and the university, and is not permitted to re-enroll. This normally results when a student, already on final academic probation, continues to perform at levels below the minimum set by the college for good academic standing, and shows no indication of being able to reach an acceptable level of performance or maintain steady progress toward completing graduation requirements. It is also an option when, in unusual cases, a student has performed poorly, and has been unresponsive to outreach efforts by college and/or university offices seeking to offer help and support.

Dietrich College Dean's Honor List

Each semester the college recognizes those students who have attained outstanding semester quality point averages by naming them to the Dietrich College dean's honor list.

Students who complete at least 45 factorable units and attain a semester QPA from 3.50 through 3.74 are named to the Dean's List, with Honors; if the semester QPA is 3.75 or higher, students are named to the Dean's List, with High Honors.

Students who complete at least 36 or up to 44 factorable units and attain a semester QPA of 3.75 or higher are named to the Dean's List, with Honors.

In addition, it is generally the case that students are not eligible for the dean's list who receive conditional grades (i.e., I [incomplete] or X [conditional failure]) at the time when final semester grades are recorded.

Course Overloads

Overloading is defined as taking more than the equivalent of five full-semester courses in one semester; for Dietrich College students this usually means registering for more than 50 units in one semester.

Eligibility to overload is defined as having a QPA of at least 3.00 in the last completed semester, based on a course load of at least 45 factorable units, and a current cumulative QPA of at least 3.00. Students new to the college and university (i.e., first-year students and new external transfer students) may not overload during their first Carnegie Mellon semester.

Eligibility to overload does not automatically allow the student to register for an overload. Rather, students must complete an overload petition, and meet with their primary academic advisor to discuss the proposed overload. If approved, the academic advisor will increase the student's unit maximum in the student record system for the relevant semester.

The first opportunity to register for a course overload is after registration week for the proposed overload semester. Registration week for the spring semester is usually the third week in November; for the fall semester, it is usually the third week in April. Consult the official academic calendar for the exact dates.

If as a result of final grades for the current semester a student approved to overload for the next semester falls below the QPA overload eligibility criteria, the academic advisor may withdraw the overload permission. Students thus affected are responsible for resolving this in consultation with their academic advisor.

Physical Education and StuCo* Courses

A maximum of nine units of credit for any combination of Physical Education (69-xxx) and StuCo (98-xxx) courses may be counted as credit toward graduation requirements. Physical Education and StuCo courses are not included when calculating a student's QPA or when calculating units to determine eligibility to carry a course overload.

* StuCo (<http://www.cmu.edu/stuco>) refers to "student led courses" — i.e., courses designed by students, and approved to be offered for academic credit.

Course Failures and Course Repetitions

Students who fail a required course must repeat and pass it (or take and successfully complete another approved course that fulfills the requirement). If a failed course is a prerequisite to more advanced course

work within a particular course sequence, the failed course must in general be repeated before moving on to the higher level course. Exception: Dietrich College freshman seminars may not be repeated, or replaced by a second seminar. Dietrich College students who do not successfully complete their freshman seminar must select and successfully complete an additional course from one of the college's general education categories.

Failed courses that are repeated and passed, or courses that are passed but repeated in order to obtain a higher grade, are not replaced on the student's record. Both course grades remain on the record, and are included in calculating the student's QPA. Students who repeat a course that they have already passed will not be able to apply the second set of units for the course toward graduation requirements.

Internships-for-Credit

An internship-for-credit is a supervised, professional work experience with clear links to a student's academic program, performed primarily or totally outside a regular course structure, and for which a student earns academic credit. Students doing an internship for academic credit must be registered through the academic department of the faculty member supervising the internship, and must register for the internship course during the term (including the summer) when the internship work is being performed. There is no additional tuition charge for internships that are taken during the academic year. Students registered for internships during the summer will be billed for tuition at the per-unit rate set by the university.

To receive academic credit, the internship:

- requires the involvement of a Carnegie Mellon faculty sponsor and an on-site supervisor in the design and evaluation of the internship;
- may include regular or periodic meetings between the student, the faculty sponsor, and/or the internship site supervisor to monitor progress;
- requires an end-product for submission to the faculty sponsor. This usually takes the form of a paper, but may also include a presentation, or some other approved form;
- can be taken for a regular letter grade by registering for the internship course through the sponsoring department. With department approval, the internship may be counted toward program requirements.
- can vary from 3-18 units in any one semester, and is limited only by the college rule of a maximum of 27 units of internship credit that can be applied to graduation requirements.

Policies and practices regarding internships-for-credit vary among academic departments. Departments are not obligated to allow internship credit for its majors, and are free to determine whether an internship may be used to fulfill requirements or serve only as an elective. An internship-for-credit is a graded experience. Each department will determine appropriate criteria for the grade if an internship is approved for credit.

Credits are earned according to the following scale: 9 units = the equivalent of 1 day (9-12 hours) per week during a semester (100 hours), 18 units = the equivalent of 2 days (12-20 hours) per week during a semester (200 hours). A Dietrich College student may not earn more than 18 units of internship credit during a semester or count more than 27 units of internship credit toward fulfillment of graduation requirements.

When the internship sponsor requires that a student receive academic credit from the home institution, the student should contact the Dietrich College Associate Dean for Undergraduate Studies for information and advice about available options.

Dietrich College Credit Policy for Non-Carnegie Mellon Courses

The following policies govern the practice of Dietrich College undergraduates taking courses elsewhere and requesting that credits for these courses transfer to their Carnegie Mellon University academic record. Courses taken elsewhere will be considered for transfer credit if the institution offering them is fully accredited, and if the courses in question are judged to be acceptable for the purposes proposed by the student.

Limits

Once a student enrolls in the university as a degree candidate, he or she may take a maximum of five courses (or their rough unit equivalent) elsewhere and transfer these back for credit toward their Carnegie Mellon degree.

No courses may be transferred and be substituted for the following general education requirements:

- 76-101 Interpretation and Argument or 76-100 Reading and Writing in an Academic Context

- 79-104 Global Histories
- 36-201 Statistical Reasoning and Practice
- 99-101 Computing @ Carnegie Mellon or 99-102 Computing @ Carnegie Mellon
- Freshman Seminar requirement

In addition, no more than two courses from another institution may be counted for Dietrich College general education requirements; no more than one course from another institution may count in any one general education category (e.g., "communicating," "reflecting," etc.)

Exceptions

These limits do not apply to courses and credits approved through Advanced Placement examinations, International Baccalaureate examinations, cross-registration through the Pittsburgh Consortium for Higher Education (PCHE), Washington Semester program, and approved study abroad or exchange programs. Exceptions to these restrictions may be made only by way of written petition to the Dietrich College Council (c/o the Dietrich College Academic Advisory Center).

Grades

Courses taken elsewhere must be taken for a regular letter grade (not pass/no credit or pass/fail) in order to be granted transfer credit. Students must earn a final grade of at least "C" in order for the credit to transfer. A "C-" grade is not transferable when its equivalency is below a 2.00 on a 4.00 scale, or 70%. Only units, not grades, transfer for courses taken elsewhere, and thus do not affect a student's Carnegie Mellon QPA. Courses offered elsewhere only on a "pass/fail" basis are not eligible for CMU transfer credit.

External Transfer Students

For students entering Carnegie Mellon and Dietrich College as external transfers, the same five-course limit applies after they become Carnegie Mellon degree candidates, unless their transfer credits reach the 180-unit limit for transfer credit stipulated by university policy. A candidate for the bachelor's degree must complete at the university a minimum of four semesters of full-time study, or the equivalent of part-time study, comprising at least 180 units of coursework. If a degree has already been obtained at another institution, courses that count toward that degree may not be used again as transfer credit toward a Carnegie Mellon University undergraduate degree.

Internal Transfer Students

This policy applies retroactively to students who enter Dietrich College through internal transfer. Courses previously approved for transfer credit may be re-evaluated for consistency with relevant Dietrich College or program policies and standards.

Students on Academic Suspension

Subject to the college's policy limiting transfer course credit, students on academic suspension from Dietrich College will be permitted to receive credit for no more than three courses per semester taken elsewhere, and no more than a total of five courses elsewhere, while on suspension. Approval to take these courses for credit is to be obtained in advance.

While on academic suspension, students are considered to be on a mandatory "leave of absence" and are governed by College and University policies concerning leaves of absence and withdrawals (<http://www.cmu.edu/hub/registration/leave.html>).

Dietrich College Department Limits

Dietrich College academic departments may not exceed these college limits, but may impose stricter limits regarding courses that students propose to take elsewhere to fulfill major requirements.

Double-Counting Courses

Double-counting refers to instances when a course taken to fulfill one requirement counts simultaneously toward a requirement in another major or minor program. While the college encourages study in complementary areas where majors and minors frequently share common requirements, it also wants to keep clear the meaning and integrity of the labels "major" and "minor." To preserve the integrity of these definitions, double-counting is permitted in Dietrich College on a very limited basis, and only in those instances when the course(s) in question represent only a small portion of the second program.

The college and its departments have developed program-specific guidelines for this practice that appear throughout the Dietrich College section of this catalog, and particularly in the case of major and minor programs that students frequently pursue in combination.

Graduation Requirements

Eligibility for graduation in Dietrich College requires that a student:

1. complete all general education requirements,
2. complete all course requirements in a primary major,
3. achieve a cumulative quality point average of at least 2.00 for all courses taken (or, alternatively, for all courses taken after the 1st year),
4. earn at least 360 units with a minimum of 180 units taken at Carnegie Mellon University,
5. be recommended (certified) for graduation by the faculty of the student's primary major department,
6. meet all financial obligations to the university, and
7. qualify for graduation within eight years of the date on which the degree is granted.

The college reserves the right to modify these academic standards, regulations, and protocols.

Graduation with University Honors

Dietrich College students who achieve an overall QPA of at least 3.50 will be recommended for graduation with university honors.

Graduation with College Honors

Students who successfully complete a senior honors thesis under the auspices of the Dietrich College senior honors program qualify for graduation with Dietrich College honors.

Dietrich College Interdisciplinary Majors

When addressing complex issues, we often rely on approaches that take advantage of a variety of relevant disciplines. The college houses the special category of "interdepartmental majors" for programs where this interdisciplinary approach is most pronounced and in which the varied disciplinary perspectives are most fully integrated. These majors are presented here separately, rather than as departmentally-based options, to reflect and underscore their sponsorship by more than one academic department and the unique features that follow from this structure.

Interdepartmental majors are administered by the academic department of the major's faculty advisor.

The Major in Economics and Mathematical Sciences

Faculty Advisor: Carol Goldberg
Office: GSIA 133
Email: cg28@andrew.cmu.edu

The B.S. in Economics and Mathematical Sciences (<http://coursecatalog.web.cmu.edu/dietrichcollegeofhumanitiesandsocialsciences/undergraduateeconomicsprogram/#bsineconomicsandmathematicalsciencescurriculum>) is a collaborative effort between the Department of Mathematical Sciences and the Undergraduate Economics Program. Combining advanced mathematics with advanced economic theory is the hallmark of this curriculum. The curriculum provides students with courses that complement and develop depth of understanding of economic theory, applied economics, and applied mathematics. This major offers an integrated curriculum, guiding students through a program of coursework that exploits and builds upon the synergies between mathematics and economics. This degree program equips students with the mathematical tools that are essential for success in Ph.D. programs in economics; mathematics; and key functional areas of business including finance, accounting, marketing, and information systems. Students pursuing this degree will be well prepared for the beginning of their research careers in academia, government, and industry. There are a limited number of student slots in this program; interested students may apply as early as their sophomore year.

The Major in Economics and Statistics

Academic Advisor: Paige Houser
For questions about Economics courses contact: Carol Goldberg or Kathleen Conway
For questions about Statistics courses contact: Rebecca Nugent or Paige Houser

Office: Baker Hall 132A
Email: acadcoord@stat.cmu.edu

The Major in Economics and Statistics provides an interdisciplinary course of study aimed at students with a strong interest in the empirical analysis of economic data. With joint curriculum from the Department of Statistics and the Undergraduate Economics Program, the major provides students with a solid foundation in the theories and methods of both fields. Students in this major are trained to advance the understanding of economic issues through the analysis, synthesis and reporting of data using the advanced empirical research methods of statistics and econometrics. Graduates are well positioned for admission to competitive graduate programs, including those in statistics, economics and management, as well as for employment in positions requiring strong analytic and conceptual skills - especially those in economics, finance, education, and public policy.

The requirements for the B.S. in Economics and Statistics are the following:

I. Prerequisites 38-39 units

1. Mathematical Foundations 38-39 units

Calculus

21-120	Differential and Integral Calculus	10
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and one of the following three:

21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10

21-257	Models and Methods for Optimization	9
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and one of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

Note: Passing the MSC 21-120 assessment test is an acceptable alternative to completing 21-120.

Note: Taking both 21-111 and 21-112 is equivalent to 21-120. The Mathematical Foundations total is then 48-49 units. The Economics and Statistics major would then total 201-202 units.

Linear Algebra

One of the following three courses:

21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	10
21-242	Matrix Theory	10

Note: 21-241 and 21-242 are intended only for students with a very strong mathematical background.

II. Foundations 18-27 units

2. Economics Foundations 9 units

73-100	Principles of Economics	9
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3. Statistical Foundations 9-18 units

Sequence 1 (For students beginning their freshman or sophomore year)

36-201	Statistical Reasoning and Practice	9
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and one of the following:

36-202	Statistical Methods	9
36-208	Regression Analysis	9
36-309	Experimental Design for Behavioral and Social Sciences	9

Or extra statistical elective**

*Acceptable equivalents for 36-201 are 36-207 (70-207), 36-220 and 36-247.

**Students who enter the program with 36-225/36-226 should discuss options with their advisors.

Sequence 2 (For students beginning later in their college career)

Advanced

Choose one of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9

III. Disciplinary Core 126 units

1. Economics Core 36 units

73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
73-270	Writing for Economists	9
73-374	Econometrics II	9

2. Statistics Core 36 units

36-225 Introduction to Probability Theory ^{**} 9
and one of the following two courses:

36-226 Introduction to Statistical Inference ^{*} 9
36-326 Mathematical Statistics (Honors) ^{*} 9

and both of the following two courses:

36-401 Modern Regression ^{*} 9
36-402 Advanced Methods for Data Analysis 9

*In order to be a major in good standing, a grade of C or better is required in 36-225 (or equivalents), 36-226 or 36-326 and 36-401. Otherwise you will not be allowed to continue in the major.

#It is possible to substitute 36-217 or 21-325 for 36-225. (36-225 is the standard introduction to probability, 36-217 is tailored for engineers and computer scientists, and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.)

3. Computing 9 units

36-350 Statistical Computing ^{*} 9

*A higher level Computer Science course approved by your Academic Advisor may be used as a substitute.

4. Advanced Electives 45 units

Students must take three advanced Economics elective courses (numbered 73-300 through 73-495, excluding 73-374, 73-407 and 73-450) and two advanced Statistics elective courses (numbered 36-303, 36-315, or 36-410 through 36-495).

Total number of units for the major 182-192 units

Total number of units for the degree 360 units

Sample Program

The following sample program illustrates one way to satisfy the requirements of the Economics and Statistics Major. Keep in mind that the program is flexible and can support other possible schedules (see footnotes below the schedule).

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	36-202 Statistical Methods	21-122 Integration and Approximation **	21-240 Matrix Algebra with Applications
36-201 Statistical Reasoning and Practice	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
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Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-402 Advanced Methods for Data Analysis	Statistics Elective	Economics Elective
36-401 Modern Regression	73-270 Writing for Economists	Economics Elective	Statistics Elective
73-374 Econometrics II	Economics Elective	-----	-----
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*In each semester, ----- represents other courses (not related to the major) which are needed in order to complete the 360 units that the degree requires.

** Students can also take 21-127 or 21-257. Students should consult with their advisor.

73-155 is not required but it is recommended by the Economics department.

Prospective PhD students might add 21-127 fall of sophomore year, replace 21-240 with 21-241, add 21-260 in spring of junior year and 21-355 in fall of senior year.

Students who elect Economics and Statistics as a second major must fulfill all Economic and Statistics degree requirements. Majors in many other programs would naturally complement a Statistics Major, including Business Administration, Social and Decision Sciences, Policy and Management, Social & Political History, and Psychology.

With respect to double-counting courses, it is departmental policy that students must have at least six courses (three Economics and three Statistics) that do not count for their primary major. If students do not have at least six, they typically take additional advanced electives.

Students are advised to begin planning their curriculum (with appropriate advisors) as soon as possible. This is particularly true if the other major has a complex set of requirements and prerequisites.

Additional Major in Environmental Policy

Faculty Director: John Soluri
Office: Baker Hall 240
E-mail: jsoluri@andrew.cmu.edu

The additional major in Environmental Policy focuses on human - environment interactions from a multitude of disciplinary perspectives. The curriculum draws on the expertise of faculty across several Carnegie Mellon colleges in order to provide students with the interdisciplinary background and skills necessary to understand environmental problems and the means to mitigate them. It emphasizes three general areas: (1) natural science and technology; (2) social sciences; and (3) the humanities. The flexible curriculum features training in research methods; a set of core courses on fundamental environmental issues including energy, pollution, and biological diversity; and a project course experience geared toward policy formulation. The total units required are 121.

Note that some courses carry prerequisites and/or reserve seats for primary majors. Students interested in pursuing the additional major must meet beforehand with the Faculty Director and their home unit academic advisor in order to evaluate the feasibility of completing the additional major and to map out a course of study. Double counting follows guidelines set by the Dietrich College. Students are encouraged to be alert to new course offerings; every effort will be made to find equivalent courses that meet student interest when done in consultation with the Faculty Director.

Prerequisites (55-57 units)

Complete ALL of the following courses:

	Units
21-111 Calculus I-(or equivalent)	10
36-201 Statistical Reasoning and Practice	9
36-202 Statistical Methods	9

Complete THREE of the following courses:

03-121 Modern Biology	9
03-124 Modern Biology Laboratory-(03-121 is corequisite)	9
03-125 Evolution	9
09-103 Atoms, Molecules and Chemical Change	9
09-105 Introduction to Modern Chemistry I	10
09-106 Modern Chemistry II	10

Disciplinary Perspectives: Complete TWO of the following courses (18 units)

09-510 Chemistry and Sustainability	9
73-148 Environmental Economics	9
76-319 Environmental Rhetoric	9
79-374 American Environmental History: Critical Issues	9

Thematic Electives: Complete TWO of the following courses (18 units)

12-100 Introduction to Civil and Environmental Engineering	12
19-101 Introduction to Engineering and Public Policy	12
19-424 Energy and the Environment	9
60-203 Concept Studio: EcoArt	10
76-395 Science Writing	9
79-372 Perspectives on the Urban Environment	9

79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
80-348	Health Development and Human Rights	9
88-223	Decision Analysis and Decision Support Systems	9
88-302	Behavioral Decision Making	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
90-765	Cities, Technology and the Environment	6
90-798	Environmental Policy & Planning	12
90-808	Energy Policy	6

(90-xxx Heinz College courses open only to seniors)

Research and Analytical Methods: Complete TWO of the following courses (18 units)

		Units
36-309	Experimental Design for Behavioral and Social Sciences	9
79-380	Ethnographic Methods	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
88-220	Policy Analysis I	9
88-251	Empirical Research Methods	9
88-252	Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9
88-432	International Policy Decision Modeling Workshop	9

Project Course: Complete ONE of the following courses (12 units)

19-451	EPP Projects (pre-approved topics)	12
19-452	EPP Projects (pre-approved topics)	12

The Major in Ethics, History, and Public Policy

Alex John London, Director
Office: Baker Hall 150A
Email: ajlondon@andrew.cmu.edu

<http://www.cmu.edu/hss/ehpp/>

The B.A./B.S. in Ethics, History, and Public Policy is an interdepartmental major offered jointly by the Departments of History and Philosophy. It prepares students for leadership positions by providing them with a rigorous, interdisciplinary humanistic and social-scientific education. It also serves as an excellent springboard for graduate study in a wide variety of disciplines such as law, public policy, ethics, and advocacy. The program focuses equally on the historical understanding of how modern-day problems have evolved, and the importance of developing clear criteria for ethical decision-making. The capstone project course provides students with the opportunity to engage with real-world public policy challenges using the methods, theories, and knowledge that they have gained through the major. Offered jointly by the departments of History and Philosophy, the B.A./B.S. in EHPP encourages specialization, internship experiences, and research in a wide range of policy areas.

Curriculum

Students graduating with a primary major in Ethics, History, and Public Policy may elect to receive either a Bachelor of Arts or a Bachelor of Science Degree (additional requirements apply; see below). Basic requirements include 120 units encompassing 9 units in Economics, 36 units in History, 36 units in Philosophy, 27 units of elective courses, and a 12-unit senior capstone course. This program may also be taken as an additional (e.g., second) major.

I. Economics Requirement 9 units

Choose one of the following:

73-100	Principles of Economics	9
88-220	Policy Analysis I	9

3

II. History Core 36 units

Choose one 9-unit course from each category below:

Policy History (9 units)

79-300	History of American Public Policy	9
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U.S. History (9 units)

79-240	The Development of American Culture	9
79-249	20th Century U.S. History	9

Non-U.S. History (9 units)

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-307	Religion and Politics in the Middle East	9

Historical Methods and Approaches (9 units)

79-200	Introduction to Historical Research	9
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III. Philosophy Core 36 units

Choose one 9-unit course from each category below. No more than 18 units at the 100 level may be counted toward this requirement.

Ethics (9 units)

80-130	Introduction to Ethics	9
80-230	Ethical Theory	9

Political Philosophy (9 units)

80-135	Introduction to Political Philosophy	9
80-235	Political Philosophy	9

Foundations of Social Science (9 units)

80-221	Philosophy of Social Science	9
80-321	Causation, Law, and Social Policy	9
80-324	Philosophy of Economics	9
80-337	Philosophy, Politics & Economics	9

Applied Philosophy (9 units)

80-136	Social Structure, Public Policy & Ethics	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
80-335	Deliberative Democracy: Theory and Practice	9
80-348	Health Development and Human Rights	9
80-447	Global Justice	9

IV. Senior Capstone Project Course 12 units

79-449	EHPP Project Course [cross-listed]	12
80-449	EHPP Project Course	12

The Ethics, History and Public Policy Project Course is required for the Ethics, History and Public Policy major and is taken in the fall semester of the senior year. In this capstone course, Ethics, History and Public Policy majors carry out a collaborative research project that examines

a compelling current policy issue that can be illuminated with historical research and philosophical and policy analysis. The students develop an original research report based on both archival and contemporary policy analysis and they present their results to a client organization in the community.

V. Elective Courses 27 units

Choose any three courses from any category or categories shown below.

Engineering and Public Policy (some courses have prerequisites; see EPP catalog listing)

19-424	Energy and the Environment	9
19-426	Environmental Decision Making	9
19-448	Science, Technology & Ethics	9

Business

70-311	Organizational Behavior	9
70-321	Negotiation and Conflict Resolution	9
70-332	Business, Society and Ethics	9
70-364	Business Law	9
70-365	International Trade and International Law	9
70-430	International Management	9

Economics (some courses have prerequisites; see Economics catalog listing)

73-148	Environmental Economics	9
73-310	Evolution of Economic Ideas and Analysis	9
73-352	Public Economics	9
73-358	Economics of the Environment and Natural Resources	9
73-359	Benefit-Cost Analysis	9
73-365	Firms, Market Structures, and Strategy	9
73-372	International Money and Finance	9
73-375	History of Money and Monetary Policy	9
73-408	Law and Economics	9
73-476	American Economic History	9

English

76-492	Rhetoric of Public Policy	9
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History

Courses from the EHPP History Core (above) may be taken as electives only if they are not being used to fulfill the core requirement. Double counting is not permitted.

79-217	The War in Vietnam	9
79-221	Development and Democracy in Latin America	9
79-231	American Foreign Policy: 1945-Present	9
79-233	The United States and the Middle East since 1945	9
79-242	African American History: Reconstruction to the Present	9
79-253	American Massacres in History and Memory	6
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-296	Perspectives on Social Protest	9
79-298	Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal	6
79-299	Trafficking Persons: Children in a Global Context	9
79-301	History of Surveillance: From the Plantation to Edward Snowden	6
79-302	Drone Warfare: Ethics, Law, Politics, History, and Strategy	6
79-303	Pittsburgh and the Transformation of Modern Urban America	6
79-305	Moneyball Nation: Data in American Life	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-312	International Human Rights Institutions in Theory and Practice	6
79-320	Women, Politics, and Protest	9
79-325	U.S. Gay and Lesbian History	6
79-331	Body Politics: Women and Health in America	9

79-338	History of Education in America	9
79-339	Juvenile Delinquency and Film (1920 to "The Wire")	9
79-340	Juvenile Delinquency and Juvenile Justice	9
79-342	Introduction to Science and Technology Studies	9
79-349	The Holocaust in Historical Perspective	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-359	Terrorism and U.S. National Security	6
79-371	African American Urban History	9
79-374	American Environmental History: Critical Issues	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
79-383	Epidemics, Disease, and Public Health	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
79-389	Stalin and Stalinism	9

Philosophy

Courses from the EHPP Philosophy Core (above) may be taken as electives only if they are not being used to fulfill the core requirement. Double counting is not permitted.

80-256	Modern Moral Philosophy	9
80-305	Rational Choice	9
80-405	Game Theory	9

Institute for Politics and Strategy

84-310	International Political Economy and Organizations	9
84-380	Grand Strategy in the United States	9
84-393	Legislative Decision Making: U.S. Congress	9
84-402	Judicial Politics and Behavior	9

Social and Decision Sciences

88-223	Decision Analysis and Decision Support Systems	9
88-281	Topics in Law: 1st Amendment	9
88-343	Economics of Technological Change	9
88-345	Perspectives on Industrial Research and Development	9
88-347	Complex Technological Systems: Past, Present, and Future	9
88-371	Entrepreneurship, Regulation and Technological Change	9
88-387	Social Norms and Economics	9
88-423	Institutions, Entrepreneurship, and Innovation	9
88-444	Public Policy and Regulation	9

VI. Bachelor of Science Option

Students may elect to earn a Bachelor of Science rather than a Bachelor of Arts degree by completing two courses from the list below, or by petitioning the Director of EHPP to accept equivalent courses as substitutions.

21-257	Models and Methods for Optimization	9
36-202	Statistical Methods	9
or 36-208	Regression Analysis	
36-207	Probability and Statistics for Business Applications	9
36-303	Sampling, Survey and Society	9
36-309	Experimental Design for Behavioral and Social Sciences	9
80-305	Rational Choice	9
88-251	Empirical Research Methods	9

Additional Major

The B.A./B.S. in Ethics, History, and Public Policy may be scheduled as an additional major in consultation with the Director of Ethics, History, and Public Policy, Professor Alex John London, ajlondon@andrew.cmu.edu.

Ethics, History, and Public Policy Sample Curriculum

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
Core requirement in Economics	Core requirement in History or Philosophy	Capstone Course	EHPP Elective Course
Core requirement in History or Philosophy	Core requirement in History or Philosophy	EHPP Elective Course	Second Course (open)
Core requirement in History or Philosophy	Core requirement in History or Philosophy	EHPP Elective Course	Third Course (open)
Core requirement in History or Philosophy	Core requirement in History or Philosophy	Fourth Course (open)	Fourth Course (open)
Core requirement in History or Philosophy	Fifth Course (open)	Fifth Course (open)	Fifth Course (open)

The above sample program is presented as a two-year (junior-senior year) plan for completing EHPP major requirements. Its purpose is to show that this program can be completed in as few as two years; not that it must be. Students may enter the EHPP major, and begin major course requirements, as early as the start of the sophomore year, or even in the first year. Students should consult their advisor when planning their program.

The Major in Information Systems

Faculty Program Director: Randy S. Weinberg
Office: Porter Hall 224C, rweinberg@cmu.edu
Program Advisor: Carol Young
Office: Porter Hall 222F, caroly@cmu.edu
Faculty: C.F. Larry Heimann, Jeria Quesenberry, Raja Sooriamrthi

Information Systems (IS) is a unique and innovative undergraduate interdisciplinary program, drawing on a wide range of exciting college and university strengths. IS is an internationally recognized undergraduate major for students who want to design and implement effective solutions to meet organizational and management needs for information and decision support. IS majors learn how elements of organizations, technology, economics, social aspects and human interaction work together to create effective computer-based information systems to affect real outcomes. Graduates of the Program are ideally situated to take a leading role in managing and shaping our information-based future.

For full program information, go to The Major in Information Systems (p. 250).

The Major in Linguistics

Tom Werner, Director
Office: Baker Hall 155F
Email: twerner@andrew.cmu.edu

Linguistics is the study of human language, and it encompasses a broad spectrum of research questions, approaches and methodologies. Some linguists are concerned with the cognitive aspects of language learning, production and comprehension; some are concerned with language as a social and cultural phenomenon; others engage in the analysis of linguistic form and meaning, some from a functional and others from a formal perspective. There are also computational approaches to linguistics with both applied and theoretical goals.

The major in Linguistics reflects the multidisciplinary character of the field and of the Linguistics faculty here at Carnegie Mellon, offering a program which provides students with the fundamental tools of linguistic analysis while maintaining a focus on the human context in which language is learned and used. The major is available as either a primary major or an additional major. It is an ideal choice for students with a general interest in their own or other languages, and combines well thematically with studies in any of the departments represented in the major.

Curriculum

The Linguistics major requires a total of 12 courses, which includes 2 semesters of language study. In addition, primary majors in Linguistics are required to write a Senior Thesis in their final year. At least three courses (not including specific language courses) must be at the 300-level or higher. All courses counted towards the major must be taken for a letter grade and passed with a grade of "C" or above. For Dietrich College students, up to 2 of these courses may be counted also as satisfying the college's general education requirements (as long as the double-counting maximum established by the college is not exceeded), with permission of the major director. Students from other colleges may fulfill their Humanities requirements using courses taken towards the Linguistics Major. However, no courses may be counted simultaneously towards the Linguistics Major and any other major.

Introductory course

80-180 Nature of Language 9

Fundamental Skills

Take **one** course from **each** of the following core subject areas:

Sounds

80-282 Phonetics and Phonology I 9

Structure

76-389 Rhetorical Grammar 9

80-280 Linguistic Analysis 9

80-285 Natural Language Syntax 9

Meaning

80-381 Meaning in Language 9

80-383 Language in Use 9

76-385 Introduction to Discourse Analysis 9

Breadth

Take **one** course from **each** of the following breadth subject areas:

Area 1: Language Learning and Language Cognition

76-420 Process of Reading and Writing 9

82-280 Learning About Language Learning 9

82-383 Second Language Acquisition: Theories and Research 9

82-585 Topics in Second Language Acquisition 9

85-354 Infant Language Development 9

85-421 Language and Thought 9

Area 2: Discourse, Society and Culture

76-318 Communicating in the Global Marketplace 9

76-385 Introduction to Discourse Analysis 9

76-386 Language & Culture 9

82-273 Introduction to Japanese Language and Culture 9

82-305 French in its Social Contexts 9

82-311 Arabic Language and Culture I 9

82-312 Arabic Language and Culture II 9

82-333 Introduction to Chinese Language and Culture Var.

Electives

Take **four** additional electives. These can be **additional courses from the Fundamental Skills courses or Breadth courses listed above**, or **any other course which is approved** by the Director as a linguistics elective. Listed below are the additional electives taught on a regular basis. **Additional appropriate courses** are offered irregularly or on a one-off basis. The Director will provide students with a list of possible electives each semester, and will assist students in selecting electives which are consistent with their goals and interests.

76-373 Argument 9

76-378 Literacy: Educational Theory and Community Practice 9

76-451 Topics in Language Study 9

76-476 Rhetoric of Science 9

80-281 Language and Thought 9

80-283 Syntax and Discourse 9

80-284 Invented Languages 9

80-286 Words and Word Formation: Introduction to Morphology 9

80-287 Historical and Comparative Linguistics 9

80-380 Philosophy of Language 9

80-382 Phonetics and Phonology II 9

80-384 Linguistics of Turkic Languages 9

80-385 Linguistics of Germanic Languages 9

82-373 Structure of the Japanese Language 9

82-388 Understanding Second Language Fluency 9

82-442 Analysis of Spoken Spanish 9

82-444 The Structure of Spanish 9

82-476 Japanese Discourse Analysis 9

82-480 Social and Cognitive Aspects of Bilingualism 9

11-411	Natural Language Processing	12
11-716	Graduate Seminar on Dialog Processing	6
11-721	Grammars and Lexicons	12
11-722	Grammar Formalisms	12
11-761	Language and Statistics	12
11-762	Language and Statistics II	12
15-492	Special Topic: Speech Processing	12

Language Requirement

Students must successfully complete two semesters of consecutive language courses. (Note that students may not 'test out' of this requirement. However, language courses taken at other institutions or as part of a study abroad program will typically substitute for a semester of language study.)

Senior Thesis [primary majors only]

Primary majors must complete a senior thesis (a workload equivalent to a 12-unit course) during their senior year. Topics must be approved by an advisor, who will work with the student and guide the thesis project.

Notes

- Course numbers 82-305, 82-311, 32-312, 82-373, 82-442, 82-444, 82-476 are taught in the language of analysis.
- All 11-xxx and 15-xxx courses have significant Computer Science prerequisites. Interested students should check with the course instructor before registering.
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- Language specific "Language and Culture" courses may be taken either as electives or towards the second breadth area. However only one such course per language area may be counted towards the major.

The Major in Psychology and Biological Sciences

This unified major is intended to reflect the interdisciplinary nature of our current research in the fields of psychology and biology, as well as the national trend in some professions to seek individuals broadly trained in both the social and natural sciences. Students entering from the Dietrich College of Humanities and Social Sciences will earn a Bachelor of Science in Psychology and Biological Sciences. Students entering from the Mellon College of Sciences receive a Bachelor of Science in Biological Sciences and Psychology. Students entering from the Science and Humanities Scholars (SHS) program can complete the SHS educational core and choose either departmental order for their diploma.

Pre-Major Requirements

The unified major specifies particular pre-major requirements in the areas of mathematical sciences and statistics, natural science, and computational reasoning. Particular courses are specified in these areas because they are prerequisites for courses required in the major and therefore they are the most efficient way to complete the general education requirements for either Dietrich College or SHS. All other general education categories can be filled in any way that satisfies the requirements of the student's college or of the SHS program.

The major in Psychology and Biological Sciences is offered only as a B.S. degree. Full curriculum requirements can be viewed here (p. 285).

Student-Defined Major Program

Joseph E. Devine, Director; Associate Dean for Undergraduate Studies
Office: Baker Hall 154F
Email: jd0x@andrew.cmu.edu
<http://www.hss.cmu.edu/studentdefinedmajor.html>

For Dietrich College students whose educational goals cannot be as adequately served by the curricula of existing majors, the college offers the opportunity to self-define a major. The procedure for establishing such a major centers on a written proposal, submitted to the Dietrich College Dean's Office. This proposal consists of two parts:

Major description and rationale. A description of the components of the proposed program of study; a presentation of the objectives of the program of study, how it represents a coherent and (given available faculty, courses, and other resources) viable course of study, and the reason(s) why these objectives cannot be accomplished within one or more of the college's existing majors.

The curriculum. Presentation of a complete outline of all courses that will comprise the requirements for the major. These courses should be categorized in two ways: first, according to that component of the major program to which each belongs (e.g., mathematical prerequisites; research methods; theoretical perspectives; etc.); and second, a semester-by-semester outline that indicates when each course is to be taken (or, for any already taken, when taken and grade received). In addition to courses taken at Carnegie Mellon, the major's curriculum may include courses taken (or to be taken) at other schools, related projects or internships, or programs of study abroad. The minimum requirements for graduation is, as with all majors in the college, 360 units of credit and completion of the Dietrich College general education program.

Proposals and curricula are evaluated for clarity of focus, coherence and depth in related areas, and viability. Proposals should generally be developed no later than the sophomore year, and approved majors begin their program generally no later than the junior year.

The student-defined option is also possible to propose as an additional major or minor. These options extend to undergraduates from all Carnegie Mellon colleges.

Dietrich College Interdisciplinary Minors

Dietrich College interdepartmental minors are programs whose content and components span two or more academic departments to form coherent patterns of study.

A number of interdepartmental minors are offered by Dietrich College and are, in general, available to all Carnegie Mellon undergraduate students. As well, there are numerous other minors offered by other colleges in the university that are generally available to Dietrich College students. The full list of minors available to Carnegie Mellon students is located in the catalog index under "Minors."

Completion of the requirements for any of these minors is noted on the final transcript.

To declare a Dietrich College interdepartmental minor, students should contact the college's Academic Advisory Center (AAC) and the faculty advisor for that minor.

To discuss the possibility of declaring a non-Dietrich College minor, contact the advisor listed for the minor in question.

In general, unless noted, no course taken to fulfill requirements for these interdepartmental minors may apply toward any other program's requirements.

The Minor in African and African American Studies

Faculty Director: Edda L. Fields-Black
Office: Baker Hall 362
Email: fieldsblack@cmu.edu

Mission

The African and African American Studies minor introduces students to several large regions of the world: sub-Saharan Africa, the Americas, and the Caribbean. Broad geographic coverage and a comparative framework encourage students to make connections between Africa and the African Diaspora, as well as among different Diasporan communities. The minor offers undergraduates the opportunity to undertake an empirical and theoretical examination of the cultural, political, social, and historical experiences of Africans and people of African descent.

This unique transnational minor brings together several departments and colleges within the university and allows students to develop analytical skills particular to the arts, humanities, social sciences, public policy, and management. The African and African American Studies minor allow students a considerable degree of freedom in their choice of electives and independent research projects, including opportunities to study and conduct research in a relevant foreign language.

Courses taken to fulfill requirements in other major or minor programs may only be applied to this minor with permission of the Faculty Director.

Requirements

- The minor is composed of 54 units - two core courses and four elective courses.
- The elective courses must include one course that requires a research paper or project.
- Students may take an additional two core courses as electives, but not more than four total courses.
- Students must take courses in at least two of the four regions (African, African American, Latin American, and the Caribbean) between their core and elective courses.

Core Courses 18 units

Choose two from the History and/or English Department courses listed below:

African		
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-236	Introduction to African Studies	9

African American

76-232	Introduction to African American Literature	9
76-332	African American Literature: The African American Crime Novel	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9

Caribbean		
79-235	Caribbean Cultures	9

Elective Courses 36 units

African		
79-162	Freshman Seminar: "Slavery" and "Freedom" in African History?	9
79-225	West African History in Film	9
79-237	Comparative Slavery *	9
79-291	Globalization in East African History	6
79-385	The Making of the African Diaspora *	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9

82-304	The Francophone World **	9
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African American		
57-480/79-357	History of Black American Music	6
76-333	African American Studies	9
76-432	Advanced Seminar in African American Studies *	9
79-237	Comparative Slavery *	9
79-304	African Americans in Pittsburgh	6
79-371	African American Urban History	9
79-376	Doing Transnational History From Western Africa to Gullah/Geechee and Back	9

Caribbean		
79-237	Comparative Slavery *	9
79-295	Race Relations in the Atlantic World	9
79-385	The Making of the African Diaspora *	9
82-304	The Francophone World **	9

Latin American		
79-317	Art, Anthropology, and Empire	9
82-343	Latin America: Language and Culture	9
82-451	Studies in Latin American Literature and Culture	9

Notes:

* Denotes courses that require a research paper/project.

** Denotes courses taught in a foreign language

The Minor in Environmental Studies

Faculty Director: John Soluri
Office: Baker Hall 363
Email: jsoluri@andrew.cmu.edu

The minor in Environmental Studies draws on the expertise of faculty across several Carnegie Mellon colleges in order to provide students with the interdisciplinary background and skills to understand environmental problems, their origins, and the means to mitigate them. It emphasizes three general areas: (1) natural science and technology, (2) social sciences, and (3) the humanities and arts. Coursework covers key environmental topics related to energy, pollution, and biological diversity.

Note that some courses carry prerequisites and/or reserve seats for primary majors. Students interested in pursuing the minor should meet with the Faculty Director to map out a course of study. Double counting rules follows guidelines set by the Dietrich College.

Students are strongly encouraged to be on the lookout for relevant new course offerings; every effort will be made to find equivalent courses that meet student interest when done in consultation with the Faculty Director.

Curriculum 54 units

Foundation of Environmental Sciences 18 units

One course in Biology

	Units
03-121 Modern Biology or	9
03-125 Evolution	9

One course in Chemistry

09-103 Atoms, Molecules and Chemical Change 9

Perspectives on Environmental Problems (36 units distributed across the three categories listed below)

Humanities

76-319 Environmental Rhetoric	9
79-289 Animal Planet: An Environmental History of People and Animals	6
79-354 Energy & Climate: History, Science, Technology, and Policy in the US 1776-2076	9
79-372 Perspectives on the Urban Environment	9
79-374 American Environmental History: Critical Issues	9
79-384 Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
80-348 Health Development and Human Rights	9

Economics and Policy

73-148 Environmental Economics	9
88-412 Energy, Climate Change, and Economic Growth in the 21st Century	9
90-798 Environmental Policy & Planning (only open to seniors)	12
90-808 Energy Policy (only open to seniors)	6

Environmental Art, Sciences, and Technology

09-510 Chemistry and Sustainability	9
19-101 Introduction to Engineering and Public Policy	12
19-424 Energy and the Environment	9
60-203 Concept Studio: EcoArt	10

The Minor in Film and Media StudiesFaculty Advisor: David Shumway
Office to declare the minor: Baker Hall 259

Film and the electronic media have become a crucial part of contemporary culture and society; they constitute an important tool for understanding social arrangements, historical changes, and play an increasingly important role in the development of aesthetic and cultural theory. The H&SS minor in Film and Media Studies takes an interdisciplinary approach to the study of film and other electronic media. Courses provide techniques for analyzing and criticizing film and other media, for assessing their value as historical, anthropological and social scientific data, and for understanding the aesthetic and philosophical premises of various media texts. In addition, students may take courses in the processes of film-making, offered through special arrangement with the Pittsburgh Filmmakers (a non-profit media arts center, operating since 1971, that provides workshops, seminars, screenings, exhibitions, and training programs in the media and photographic arts).

Courses taken to fulfill requirements for other major or minor programs may not be applied to the Film and Media Studies Minor requirements.

Curriculum 54 units

The courses listed below are offered with at least general regularity. Participating departments may subsequently develop and offer other courses that, while not listed here, are deemed appropriate for this minor. The minor faculty advisor should be consulted (especially when the schedule of courses to be offered for a given semester becomes available) to identify such additional courses.

Introductory Course 9 units

76-239 Introduction to Film Studies (prerequisite for 76-439) 9

Required Intermediate Course 9 units

76-339 Topics in Film Studies (May be taken up to three times and counted for additional credit toward Intermediate Courses if topics differ) 9

Intermediate Courses 27 units

Complete a minimum of 27 units of course work, chosen in any combination from the following three course groups. (All courses are 9 units unless otherwise indicated).

1. Film and the Study of Society
76-238 Introduction to Media Studies 9
82-296 A Century of Russian Film 9

2. Film and Anthropology
79-278 Rights to Representation: Indigenous People and their Media 9

3. Filmmaking
76-269 Survey of Forms: Screenwriting 9
FM 200 Intermediate Filmmaking (please go to CFA 100 to register for this course)

Other 200 or 300 level courses in English, History, and Modern Languages can be counted in this category when their primary topic is film and media. Please consult the minor faculty advisor.

Advanced Courses 9 units

Complete one advanced course that concentrates on film directly or that uses it as a tool of social or cultural analysis. One additional advanced course may be taken in place of an intermediate course.

FM 301 Advanced Filmmaking (please go to CFA 100 to register for this course)

76-438 Film and Media Studies: Television 9
76-439 Seminar in Film and Media Studies 9
76-469 Advanced Screenwriting Workshop 9

The Minor in Gender StudiesFaculty Advisors: Kristina Straub and Lisa Tetrault
Office to declare minor: English, Baker Hall 259

Gender studies is an interdisciplinary field that investigates how gender is embedded in social, cultural, and political relationships. It understands gender as a category of power that intersects with other power relations, including race, class, and sexuality. Courses allow students to develop a deeper understanding of how gender operates, and to transfer the analytical skills they acquire to other courses as well as to their personal and professional lives. The minor combines coursework in some combination of the following fields: English, history, anthropology, psychology, philosophy, economics, and modern languages.

Courses taken to fulfill requirements in other major or minor programs may not be applied to the Gender Studies minor requirements (and vice versa).

Curriculum 54 units

The courses listed below are offered with at least general regularity. Participating departments may develop and offer other courses that, while not listed here, are appropriate for the study of gender. Consult the minor advisor to confirm the relevance of unlisted, gender-focused courses.

Required Introductory Courses 18 units

Complete one of the following (9 units)
76-241 Introduction to Gender Studies 9
79-331 Body Politics: Women and Health in America 9

and one of the following (9 units):

76-245 Shakespeare: Tragedies and Histories 9

76-247	Shakespeare: Comedies and Romances	9
79-244	Women in American History	9
85-221	Principles of Child Development	9

Elective Intermediate Courses 27 units

Choose three of the following courses:

76-327	Influential Women Writers	9
76-341	Gender and Sexuality in Performance	9
79-320	Women, Politics, and Protest	9
79-325	U.S. Gay and Lesbian History	6
79-331	Body Politics: Women and Health in America	9
85-350	Psychology of Prejudice	9

Elective Advanced Courses 9 units

These courses are generally offered at the advanced junior and senior level. Offerings vary from semester to semester and a list will be made available to minors prior to registration each term. For questions about courses and about how to declare a minor, contact the advisors.

Students may also take more than 9 units from the "Advanced Course" list to count for the 54 unit total. For information about additional course offerings, contact Kristina Straub, ks3t@andrew.cmu.edu, 412.268.6458 or Lisa Tetrault, tetrault@andrew.cmu.edu, 412.268.4440.

The Minor in Global Systems and Management

Faculty Advisor: Gary J. DiLisio
Office: PH 222F

Graduates across all disciplines are increasingly likely to find themselves working as part of a global development team on a wide variety of business, consumer, and intellectual products and services.

The Global Systems and Management minor (GSM) is intended for students wishing to develop skills essential for participating in emerging opportunities in global business systems, systems development, product development and global project management. GSM exposes students to contemporary issues and practices facing organizations, managers and individuals working on a global scale across political, cultural and temporal boundaries. GSM presents an opportunity for students to learn about being part of an organization that works globally with its employees, business partners, customers and supply chains.

Students will learn about global project management, outsourcing and cross-cultural communications from theoretical and practical viewpoints. An organized elective structure enables students to tailor the minor to reflect their specific interests.

Curriculum 54 units

GSM is offered jointly across the departments and programs of the Dietrich College of Humanities and Social Sciences with participation from the Tepper School of Business. The minor is administered by the Dietrich College Information Systems program. The minor requires students to complete 54 units:

- one Information Systems course: 67-329 Contemporary Themes in Global Systems (offered only in the Fall semester)
- two courses in Communications
- a combination of 27 units with at least 9 units in each of the categories of:
 - Humanities, Heritage and Culture
 - International Management

Study Abroad Options

Students are encouraged to complete a semester of study abroad. With prior approval from the GSM Advisor, study abroad courses may be applied to GSM minor requirements except for 67-329 Contemporary Themes in Global Systems. Please consult with the GSM Advisor before embarking on the semester of study abroad.

Double Counting of Courses

Students may apply one course taken to fulfill a requirement in another major or minor program toward the GSM minor.

Core Course

Required course:

67-329	Contemporary Themes in Global Systems (Fall Semester Only)	9
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Communications 18 units

Complete two courses:

70-321	Negotiation and Conflict Resolution	9
70-340	Business Communications	9
70/85/88-341	Organizational Communication	9
70-342	Managing Across Cultures	9
76-270	Writing for the Professions	9
76-318	Communicating in the Global Marketplace	9
76-386/786	Language & Culture	9
76-428	Visual Verbal Communication	9
85-375	Crosscultural Psychology	9
88-419	Negotiation	9

Humanities, Heritage and Culture (HHC) & International Management (IM) 27 units

(Complete 9 units of HHC and 18 units of IM ---OR--- 18 units of HHC and 9 units of IM)

Humanities, Heritage and Culture

Humanities Heritage and Culture consists of:

- History Department courses: 79-200 level or above covering international/regional studies that are outside of U.S. history
- Modern Languages Department courses: 82-200 level or above, covering international or regional studies but not including elementary or intermediate language courses

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-221	Development and Democracy in Latin America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-235	Caribbean Cultures	9
79-251	India/America: Democracy, Diversity, Development	9
79-254	The Jewish Diaspora in Latin America	9
79-255	Irish History	6
79-257	Germany and the Second World War	9
79-258	French History: From the Revolution to De Gaulle	9
79-259	France During World War II	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-271	Russian Studies Topics	6
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-274	19th and 20th Century Russia: Society, Art, Music and Theater	9
79-275	Introduction to Global Studies	9
79-278	Rights to Representation: Indigenous People and their Media	9
79-291	Globalization in East African History	6
79-295	Race Relations in the Atlantic World	9
79-297	Dilemmas and Controversies in Anthropology	9

79-299	Trafficking Persons: Children in a Global Context	9
79-307	Religion and Politics in the Middle East	9
79-308	Inventing the American Airplane: Technology and Military Aviation, 1898-1945	6
79-309	20th Century China Through Film	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-312	International Human Rights Institutions in Theory and Practice	6
79-323	Family, Gender, and Sexuality in European History, 500-1800	9
79-326	German History through Film	9
79-341	The Cold War in Documents and Film	9
79-349	The Holocaust in Historical Perspective	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
79-385	The Making of the African Diaspora	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
82-215	Introduction to Modern Arabic Literature and Culture	Var.
82-253	Korean Culture Through Film	9
82-273	Introduction to Japanese Language and Culture	9
82-303	Introduction to French Culture	9
82-304	The Francophone World	9
82-305	French in its Social Contexts	9
82-311	Arabic Language and Culture I	9
82-312	Arabic Language and Culture II	9
82-320	Contemporary Society in Germany, Austria and Switzerland	9
82-323	Germany, Austria and Switzerland in the 20th Century	9
82-333	Introduction to Chinese Language and Culture	Var.
82-342	Spain: Language and Culture	9
82-343	Latin America: Language and Culture	9
82-345	Introduction to Hispanic Literary and Cultural Studies	9
82-361	Italian Language and Culture I	9
82-362	Italian Language and Culture II	9
82-399	Special Topics: Russian in Context	Var.
82-415	Topics in French and Francophone Studies	9
or 82-416	Topics in French and Francophone Studies	
82-425	Topics in German Literature and Culture	9
82-431	China and the West	9
82-433	Topics in Contemporary Culture of China	9
82-441	Studies in Peninsular Literature and Culture	9
82-450	Advanced Research in Hispanic Language & Culture	9
82-456	Topics in Hispanic Studies	9
82-473	Topics in Japanese Studies	9
or 82-474	Topics in Japanese Studies	
International Management		
19-411	Global Competitiveness: Firms, Nations and Technological Change	9
67-319-67-331	Global Technology Consulting Groundwork - Technology Consulting in the Global Community (these two courses are taken sequentially)	6
70-342	Managing Across Cultures	9
70-365	International Trade and International Law	9
70-430	International Management	9
70-480	International Marketing	9
73-372	International Money and Finance	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
88-378	International Economics	9
88-384	Conflict and Conflict Resolution in International Relations	9
88-410	The Global Economy: A User's Guide	9
88-411	Rise of the Asian Economies	9

88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9
88-432	International Policy Decision Modeling Workshop	9

MINIMUM NUMBER OF UNITS REQUIRED FOR MINOR 54

Minor in Health Care Policy and Management

Sponsored by:

H. John Heinz III College
Dietrich College of Humanities and Social Sciences
Mellon College of Science

Faculty Advisors:

Jason D'Antonio, Mellon College of Science
James F. Jordan, H. John Heinz III College

The face of health care is changing. The practice of medicine is being fundamentally altered by the forces of change in public policy, health care organizations and in the industry as a whole. The role of individual professionals in this industry is changing as rapidly as the industry itself. Traditional career paths have disappeared overnight to be replaced by new opportunities that require new skills. New organizations are placing new demands on their professional and medical staffs. The criteria of efficiency and financial stability are entering the domains of diagnosis and treatment.

This minor is designed to provide students considering a career in the health professions with an understanding of how these changes are likely to affect their careers. Students will become familiar with the critical policy and management issues and will begin to learn to operate effectively in the emerging health care environment. The curriculum combines economic, organizational, managerial, historical and psychological perspectives on these issues to provide a foundation for a deepened understanding of the changing structure of health care organizations and policy.

Curriculum 60 units minimum

Seven courses (a minimum of 60 units) are required to complete this minor. Entry into the minor requires completion of 73-100 Principles of Economics or 88-220 Policy Analysis I or the equivalent by approval.

Required Courses 39 units

Students are required to take the following courses.

79-330	Medicine and Society	9
90-836	Health Systems	6
90-861	Health Policy	6
94-705	Health Economics	12

Elective Courses 27 units

Complete a minimum of 27 units.

Heinz College Courses

90-708	Healthcare Ethics	6
90-721	Healthcare Management	6
90-818	Health Care Quality & Performance Improvement	6
90-830	Introduction to Financial Management of Health Care	6
90-831	Advanced Financial Management of Health Care	6
90-832	Health Law	6
90-863	Health Policy II	6
94-706	Healthcare Information Systems	12

Humanities and Social Sciences Courses (9 units each)

76-494	Healthcare Communications	9
79-383	Epidemics, Disease, and Public Health	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
85-241	Social Psychology	9
85-442	Health Psychology	9
85-446	Psychology of Gender	9

Please note that some of these courses have prerequisites that will not count toward the completion of the requirements for this minor.

The Minor in Linguistics

Tom Werner, Director
Office: Baker Hall 155F
Email: twerner@andrew.cmu.edu

The Interdepartmental Minor in Linguistics combines courses from the departments of Philosophy, English, Modern Languages, Psychology and the Language Technologies Institute. It synthesizes the linguistics related offerings in these departments and provides students with an academic experience that reflects the interdisciplinary character of the subject.

The Minor in Linguistics requires a total of 6 courses: the introductory linguistics course; two fundamental skills courses; and three additional electives. All courses counted towards the Minor must be taken for a letter grade and passed with a grade of "C" or above.

Introductory course

80-180	Nature of Language	9
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Fundamental Skills

Take **one** course from **two** of the following core subject areas:

Sounds

80-282	Phonetics and Phonology I	9
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Structure

76-389	Rhetorical Grammar	9
80-280	Linguistic Analysis	9
80-285	Natural Language Syntax	9

Meaning

80-381	Meaning in Language	9
80-383	Language in Use	9
76-385	Introduction to Discourse Analysis	9

Electives

Take three additional linguistics courses. These can be additional courses from the Fundamental Skills categories above, or any other course which is approved by the Director as a linguistics elective. For electives taught on a regular basis, see courses listed as Breadth or Electives in the Undergraduate Catalog entry for the Linguistics Major.

The Minor in Neural Computation

Director: Dr. Tai Sing Lee
Administrative Coordinator: Melissa Stupka
Website: http://www.cnbc.cmu.edu/upnc/nc_minor/

The minor in Neural Computation is an inter college minor jointly sponsored by the School of Computer Science, the Mellon College of Science, and the Dietrich College of Humanities and Social Sciences, and is coordinated by the Center for the Neural Basis of Cognition (CNBC) (<http://www.cnbc.cmu.edu>).

The Neural Computation minor is open to students in any major of any college at Carnegie Mellon. It seeks to attract undergraduate students from computer science, psychology, engineering, biology, statistics, physics, and mathematics from SCS, CIT, Dietrich College and MCS. The primary objective of the minor is to encourage students in biology and psychology to take computer science, engineering and mathematics courses, to encourage students in computer science, engineering, statistics and physics to take courses in neuroscience and psychology, and to bring students from different disciplines together to form a community. The curriculum and course requirements are designed to maximize the participation of students from diverse academic disciplines. The program seeks to produce students with both basic computational skills and knowledge in cognitive science and neuroscience that are central to computational neuroscience.

Curriculum

The minor in Neural Computation will require a total of five courses: four courses drawn from the four core areas (A: Neural Computation, B: Neuroscience, C: Cognitive Psychology, D: Intelligent System Analysis), one from each area, and one additional depth elective chosen from one of the core areas that is outside the student's major. The depth elective can be replaced by a one-year research project in computational neuroscience. No more than two courses can be double counted toward the student's major or other minors. However, courses taken for general education requirements of the student's degree are not considered to be double counted. A course taken to satisfy one core area cannot be used to satisfy

the course requirement for another core area. The following listing presents a set of current possible courses in each area. Substitution is possible but requires approval by the director of the minor program.

A. Neural Computation

		Units
15-386	Neural Computation	9
15-387	Computational Perception	9
15-883	Computational Models of Neural Systems	12
85-419	Introduction to Parallel Distributed Processing	9
86-375	Computational Perception	9
Pitt-Mathematics-1800	Introduction to Mathematical Neuroscience	9

B. Neuroscience

03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
03-365	Neural Correlates of Learning and Memory	9
42-630	Introduction to Neuroscience for Engineers (crosslisted with 18-690)	12
85-765	Cognitive Neuroscience	Var.
Pitt-Neuroscience 1000	Introduction to Neuroscience	9
Pitt-Neuroscience 1012	Neurophysiology	9

C. Cognitive Psychology

85-211	Cognitive Psychology	9
85-213	Human Information Processing and Artificial Intelligence	9
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing	9
85-426	Learning in Humans and Machines	9
85-765	Cognitive Neuroscience	Var.

D. Intelligent System Analysis

10-601	Introduction to Machine Learning	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-386	Neural Computation	9
15-387	Computational Perception	9
15-486	Artificial Neural Networks	12
15-494	Special Topic: Cognitive Robotics	12
16-299	Introduction to Feedback Control Systems	12
16-311	Introduction to Robotics	12
16-385	Computer Vision	9
18-290	Signals and Systems	12
24-352	Dynamic Systems and Controls	12
36-225	Introduction to Probability Theory	9
36-247	Statistics for Lab Sciences	9
36-401	Modern Regression	9
36-410	Introduction to Probability Modeling	9
42-631	Neural Data Analysis	9
42-632	Neural Signal Processing	12
86-375	Computational Perception	9
86-631	Neural Data Analysis	9

Prerequisites

The required courses in the above four core areas require a number of basic prerequisites: basic programming skills at the level of 15-110 Principles of Computing and basic mathematical skills at the level of 21-122 Integration and Approximation or their equivalents. Some courses in Area D require additional prerequisites. Area B Biology courses require, at minimum, 03-121 Modern Biology. Students might skip the prerequisites if they have the permission of the instructor to take the required courses. Prerequisite courses are typically taken to satisfy the students' major or other requirements. In the event that these basic skill courses are not part of the prerequisite or required courses of a student's major, one of them can potentially count toward the five required courses (e.g. the depth elective), conditional on approval by the director of the minor program.

Research Requirements (Optional)

The minor itself does not require a research project. The student however may replace the depth elective with a year-long research project. In special

circumstances, a research project can also be used to replace one of the five courses, as long as (1) the project is not required by the student's major or other minor, (2) the student has taken a course in each of the four core areas (not necessarily for the purpose of satisfying this minor's requirements), and (3) has taken at least three courses in this curriculum not counted toward the student's major or other minors. Students interested in participating in the research project should contact any faculty engaged in computational neuroscience or neural computation research at Carnegie Mellon or in the University of Pittsburgh. A useful webpage that provides listing of faculty in neural computation is <http://www.cnbc.cmu.edu/computational-neuroscience>. The director of the minor program will be happy to discuss with students about their research interest and direct them to the appropriate faculty.

Fellowship Opportunities

The Program in Neural Computation (PNC) administered by the Center for the Neural Basis of Cognition currently provides 3-4 competitive full-year fellowships (\$11,000) to Carnegie Mellon undergraduate students to carry out mentored research in neural computation. The fellowship has course requirements similar to the requirements of the minor. Students do not apply to the fellowship program directly. They have to be nominated by the faculty members who are willing to mentor them. Therefore, students interested in the full-year fellowship program should contact and discuss research opportunities with any CNBC faculty at Carnegie Mellon or University of Pittsburgh working in the area of neural computation or computational neuroscience and ask for their nomination by sending email to Dr. Tai Sing Lee, who also administers the undergraduate fellowship program at Carnegie Mellon. See <http://www.cnbc.cmu.edu/fellowcompneuro> for details.

The Program in Neural Computation also offers a summer training program for undergraduate students from any U.S. undergraduate college. The students will engage in a 10-week intense mentored research and attend a series of lectures in neural computation. See the <http://www.cnbc.cmu.edu/summercompneuro> for application information.

The Minor in Religious Studies

Faculty Director: Allyson Creasman
Office: Baker Hall 240
Email: allysonc@andrew.cmu.edu

The Religious Studies minor offers students, a range of intellectual tools for thinking about religious ideas, behaviors and institutions. It also enables students to build a base of knowledge that extends beyond any one particular religious tradition.

The minor consists of six courses, totaling at least 54 units. Courses taken to fulfill requirements in other major or minor programs may only be applied to this minor with permission of the Faculty Director.

Curriculum 54 units

Religious Studies minors must satisfy the following requirements.

The "required" course listed below is offered regularly; the "distribution" and "elective" courses are offered with at least general regularity. Participating departments may subsequently offer other courses that, while not listed here, may satisfy requirements for this minor. The Faculty Director should be consulted to identify such additional courses (especially after the schedule of courses to be offered for a given semester becomes available).

Core Course 9 units

This required course introduces several modes of inquiry regarding religion, such as philosophy of religion, sociological and behavioral approaches to religion, historical analysis of religious subject matter, literary and critical analysis of religious texts, theological modes of thought, and anthropological treatments of religion.

79-281	Introduction to Religion	9
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Distribution Requirements 18 units

A distribution course is one that applies a particular discipline to more than one religion. Complete one course from two of the three different disciplinary approaches listed below (Historical, Philosophical, Textual). Feel free to consult with the Faculty Director about other options.

Historical Approaches

79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-307	Religion and Politics in the Middle East	9

79-353	Religious Identities and Religious Conflicts in 19th Century Europe	9
Philosophical Approaches		
80-276	Philosophy of Religion	9
Textual Approaches		
76-346	Angels and Diplomats -- Renaissance Poetry from Wyatt to Milton	9

Elective Courses 27 units

Complete courses totaling at least 27 units. In addition to the Carnegie Mellon courses listed below, electives may be chosen from among any of the courses listed above under "Distribution Requirements" that were not used to fulfill that requirement.

76-330	Medieval Literature	9
76-346	Angels and Diplomats -- Renaissance Poetry from Wyatt to Milton	9
76-430	Arthurian Romance and Its Modern Legacy	9
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-254	The Jewish Diaspora in Latin America	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-307	Religion and Politics in the Middle East	9
79-349	The Holocaust in Historical Perspective	9
79-350	Early Christianity	9
79-352	Christendom Divided: The Protestant and Catholic Reformation, 1450-1650	9
79-353	Religious Identities and Religious Conflicts in 19th Century Europe	9
80-276	Philosophy of Religion	9

Students may cross-register for relevant electives at the University of Pittsburgh, Duquesne University, or other Pittsburgh institutions with the permission of the Faculty Director for the religious studies minor.

The Minor in Science, Technology and Society

Faculty Director: Jay Aronson,
Office: Baker Hall 246B
Email: aronson@andrew.cmu.edu

This minor provides varied perspectives on the development and meaning of science and technology in modern society. The core courses enable you to explore the philosophical underpinnings, cultural and historical contexts, and economic and literary assessments of the interplay among science, technology, and society. Elective courses enable you to pursue in greater depth and variety subjects and approaches that build on both the core courses and your primary major.

Courses taken to fulfill requirements in other major or minor programs may only be applied to this minor with permission of the Faculty Director.

Curriculum 54 units

Core Courses 27 units

Complete two courses from Area 1 and one course from Area 2.

Area 1. History, Philosophy, and Social Studies of Science and Technology (18 units)

79-330	Medicine and Society	9
79-342	Introduction to Science and Technology Studies	9
79-354	Energy & Climate: History, Science, Technology, and Policy in the US 1776-2076	9
80-226	Revolutions in Science	9
80-323	Philosophy of Biology	9

Area 2. Language and Rhetoric in Science and Technology (9 units)

51-326	Photography & Family	9
76-319	Environmental Rhetoric	9
76-395	Science Writing	9
76-425	Science in the Public Sphere	9

76-476	Rhetoric of Science	9
76-492	Rhetoric of Public Policy	9

Electives 27 units

Complete three courses from the approved list of elective courses. Courses listed in Areas 1 and 2 may also be taken as electives if not already completed for an Area requirement. For a listing of approved courses, consult the description of the minor in Science, Technology and Society on the Dietrich College of Humanities and Social Sciences' webpage (<http://www.hss.cmu.edu/index.html>), or contact the Faculty Director directly at aronson@andrew.cmu.edu.

Area 3. Electives

15-xxx	Special Topics	9-12
18-482	Telecommunications, Technology Policy & Management	12
48-448	History of Sustainable Architecture	9
79-331	Body Politics: Women and Health in America	9
79-332	Medical Anthropology	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
79-383	Epidemics, Disease, and Public Health	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
80-341	Computers, Society and Ethics	9
85-380	In Search of Mind: The History of Psychology	9

The Minor in Sociology

Faculty Director, Saurabh Bhargava
Program Advisor, Connie Angermeier
Office: Porter Hall 208A
Email: cla2@andrew.cmu.edu

The Sociology minor provides the student with a solid introduction to the central concepts in sociological theory and a grounding in the methods of empirical inquiry needed to understand societies, their histories, and how they change over time. Students choose among selected topics including social psychology, work and organizations, social networks, technology and society, medical sociology, and gender and family. Exposure to these topics will help students understand and appreciate the processes by which families, groups, and organizations form and evolve over time; by which individuals affect and are affected by the society in which they live; and by which technology and institutions shape and influence society. This background in empirical tools and social theory will strengthen students' ability to enter graduate studies in sociology, social history, social science, and organizational theory; to begin professional careers involving social analysis, network analysis, data analysis of teams, groups and organizations, social analysis within journalism, political institutions, the government; and to enter the corporate environment with a thorough understanding of organizational activity.

Curriculum 54 units

In addition to the general education requirements of the student's college and the requirements of the student's major, Sociology minors must satisfy the following requirements. The Core courses comprise 18 units of the minor. One course is taken from the Organizations cluster, and one course is taken from the Methodology cluster. The Elective courses comprise 36 units of the minor. Sociology minors should consult with the program advisor to plan a course schedule prior to registration.

NOTE: The core courses are offered regularly; the elective courses are offered with at least general regularity. Participating departments may subsequently develop and offer other courses that, while not listed here, are deemed appropriate for this minor. The program advisor should be consulted (especially when the schedule of courses to be offered for a given semester becomes available) to identify such additional courses.

No more than 9 units in the Sociology minor may be counted to fulfill any other major or minor's requirements.

Core Courses 18 units

A. Organizations

Complete one course.

70-311	Organizational Behavior	9
88-260	Organizations	9

B. Methodology

Complete one course.

36-202	Statistical Methods	9
70-208	Regression Analysis	9
85-340	Research Methods in Social Psychology	9
88-251	Empirical Research Methods	9
88-252	Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9

Elective Courses 36 units

Complete four courses (a minimum of 36 units) from the following list. Two courses (18 units) must be taken from one category to complete the depth requirement. One course (9 units) must be taken from the other category. The remaining course (9 units) may be taken from either category. Appropriate courses offered by the Department of Sociology at the University of Pittsburgh (available during the academic year through cross-registration) may also be included as part of this option. Contact the Sociology program advisor for more information.

1. Sociology of Gender, Family, and Culture

70-342	Managing Across Cultures	9
79-244	Women in American History	9
79-261	Chinese Culture and Society	9
79-308	Inventing the American Airplane: Technology and Military Aviation, 1898-1945	6
79-320	Women, Politics, and Protest	9
79-323	Family, Gender, and Sexuality in European History, 500-1800	9
79-331	Body Politics: Women and Health in America	9
79-332	Medical Anthropology	9
79-339	Juvenile Delinquency and Film (1920 to "The Wire")	9
79-343	History of American Urban Life	9
79-377	Food, Culture, and Power: A History of Eating	9
80-230	Ethical Theory	9
80-245	Medical Ethics	9
80-305	Rational Choice	9
85-241	Social Psychology	9
85-446	Psychology of Gender	9

2. Sociology of Work, Organizations, and Technology

70-332	Business, Society and Ethics	9
70-414	Entrepreneurship for Engineers	9
73-331	Political Economy of Inequality and Redistribution	9
79-342	Introduction to Science and Technology Studies	9
80-341	Computers, Society and Ethics	9
88-341	Organizational Communication	9
88-345	Perspectives on Industrial Research and Development	9
88-347	Complex Technological Systems: Past, Present, and Future	9
88-371	Entrepreneurship, Regulation and Technological Change	9
88-391	Technology and Economic Growth	9
88-402	Modeling Complex Social Systems	9
88-413	Energy and Climate: History, Science, Technology, & Policy in the US 1776-2076	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9
88-419	Negotiation	9
88-423	Institutions, Entrepreneurship, and Innovation	9
88-435	Decision Science and Policy	9
88-451	Policy Analysis Senior Project	12
or 88-452	Policy Analysis Senior Project	

Note: Some courses have additional prerequisites.

Undergraduate Economics Program

Carol B. Goldberg, Executive Director of Undergraduate Economics (Tepper, Room 130)
 Kathleen Conway, Associate Director (Tepper, Room 131)
 Program Office: Tepper School of Business, Room 139
 E-mail: econprog@andrew.cmu.edu
 Advising Appointment Online Scheduler: <http://tepper.cmu.edu/undergradappt>
<http://tepper.cmu.edu/prospective-students/undergraduate/economics>

At its most fundamental level, economics is the study of how scarce resources are allocated. What will be produced and consumed, how much, and by whom? These questions are central to the well-being of people throughout the world. Economists identify, model, and analyze problems with the objective of developing practical and efficient solutions to challenges confronting society. Economists are also active participants in the processes and institutions through which economic policies are implemented. In the public arena sphere, economists contribute to design of programs and incentive systems to foster efficient implementation of policies. In the private sector, economists bring modeling and data-analytic skill to bear, both in identifying ways to enhance productive efficiency within the firm and in developing strategies to enhance effectiveness of the firm as it competes in the global marketplace. Increasingly, economists are taking advantage of advances in technology to design new exchange systems in applications as diverse as global electronic markets, kidney exchanges, pollution control, and school choice mechanisms.

Carnegie Mellon University enjoys a rich history of innovative research in the field of economics. The university has a distinctive culture that fosters collaborative, problem-oriented, theoretically rigorous, and empirically tested research. The success of this distinctive approach is manifest in the international recognition accorded past and present faculty, including nine Nobel Prizes in Economics. In the classroom, faculty bring the same rigorous, innovative approach to help develop the tremendous intellectual potential and analytic skills of students who are drawn to study economics at Carnegie Mellon. Project courses and hands-on applications in classes enable our students to gain valuable practical experience in honing their skills in economic reasoning, modeling, and data analysis.

The Undergraduate Economics Program has a unique position at Carnegie Mellon University. It is the sole undergraduate program that is a joint program of the Tepper School of Business and the Dietrich College of Humanities and Social Sciences. The combination of research strength (Tepper has been home to nine Nobel Laureates in Economics) and commitment to liberal arts and interdisciplinary studies (Dietrich has "the most creative general education program of any American university" - New York Times) provides our undergraduates with a world-class economics program.

Economics majors are considered members of both colleges and enjoy the full support and services of both. Undergraduate economics students should consult the program's website and handbook for details about applicable Tepper and Dietrich academic policies and procedures.

Educational Objectives

The Undergraduate Economics Program offers a range of degrees in economics designed to develop strong analytical skills and a solid foundation in the discipline of economics. More specifically, measurable objectives for our economics curriculum are the following:

- Students should be able to identify, explain, and use economic concepts, theories, models, and data-analytic techniques.
- Students should acquire and use knowledge of economics, mathematics, statistics, and computing flexibly in a variety of contexts, providing the foundation for success in graduate studies and careers in the public and private sectors.
- Students should be able to apply their economic tools to formulate positions on a wide range of social and economic problems and engage effectively in policy debates.
- Students should use the investigative skills necessary for conducting original economic research and participating effectively in project teams.
- Students should be able to deliver effective presentations in which they combine visual communication design with oral arguments and/or the written word.

Advising

The Undergraduate Economics Program is committed to providing students with the opportunity to have meaningful and informative discussions about their academic, intellectual, and career interests with a wide range of advisors and mentors. In college, advising meetings are not the same thing as "being sent to the principal's office" in high school. Instead, advising meetings are extended discussions which may address both immediate and long-term interests, concerns, and desires/needs. Students pursuing a degree in economics are assigned an economics advisor who meets with them on a regular basis. Any CMU undergraduate student interesting in taking an economics courses is invited to meet with an economics advisor. To facilitate scheduling advising meetings, please use the online appointment scheduler (<http://tepper.cmu.edu/undergradappt>).

The economics curriculum is cumulative; higher-level courses build upon the foundations learned in the core course. This results in students needing to be aware of course-sequencing and the schedule of classes.

Students are encouraged to meet frequently with their Undergraduate Economics Program academic advisor to ensure that their courses fulfill the requirements towards their degree and are appropriately sequenced. Historically, successful students typically checked-in with their advisor frequently and sought the advice of their academic advisor in selecting courses, pursuing additional degrees, and planning ahead for study abroad.

First-Year Advising

Most first-year students who major in economics enter the Carnegie Mellon University as Dietrich College students, and are assigned a Dietrich College Academic Advisory Center (<http://www.cmu.edu/hss/advisory-center>) (AAC) advisor. Students who are considering majoring in economics are encouraged to contact the Undergraduate Economics Program academic advisors so that they will have access to program resources; program-level advising; and the community of faculty, staff, and students.

First-year students are **not** expected to know which degree option they wish to pursue. For this reason, the first-year curricula are quite similar for the four primary degrees awarded by the program. As students become involved in their course work, participate in the extra- and co-curricular activities sponsored by the Undergraduate Economics Program, and discussions with faculty and economics advisors, the decision of which degree to pursue becomes evident.

Study Abroad

The Undergraduate Economics Program encourages students to consider enriching their undergraduate experience by studying abroad at some point during their undergraduate tenure. Studying abroad is widely defined as either study, work, internship, volunteer, or research opportunities abroad during your college career. Studying abroad provides students with not only more awareness of cultural literacies, but it further enhances their education by providing them with the opportunity to compare and contrast different economies and regimes. Many students consider their study abroad experience to be a watershed moment in their studies. With a bit of careful planning, study abroad can be worked into most any economics student's 4-year schedule.

Preparation for Professional School Programs

Many economics students will attend professional graduate school programs (e.g., DDS, JD, MBA, MD, MPP, M.Sc. Finance, etc.) immediately after graduation or within the first five years of earning their undergraduate degree. Students who are considering applying to professional graduate schools are encouraged to meet with an economics advisor early in their career at CMU. The economics advisors can provide structure and information that are invaluable during a student's intellectual and career exploration. Knowing that the choice of courses, student achievement, extra- and co-curricular activities, professional school entrance exam test scores (e.g., GMAT, LSAT, MCAT, etc), and faculty recommendations are key determinants of acceptance into these varied programs, the economics advisors will help you plan your time at CMU.

Preparation for Ph.D. Programs in Economics

The Undergraduate Economics Program has been successful in preparing students for admission into the nation's most competitive doctoral programs. The life of a researcher (whether in academia or in the private research sector) requires a set of skills that undergraduate students will begin to acquire through course work, research, and focused conversations with faculty and advisors. Doctoral programs in economics are looking for specific analytical skills. Key determinants of acceptance into these programs are the choice of courses, student achievement, research experience, graduate school entrance exam test scores (specifically the GRE), and faculty recommendations. Students who are considering pursuing a higher academic degree are encouraged to meet an economics advisor early in their career at CMU. Interested students are encouraged to look at the B.S. in Economics and Mathematical Sciences curriculum.

Curricula

In order to accommodate students' wide variety of goals, four primary degree programs are available: Bachelor of Arts in Economics, Bachelor of Science in Economics, Bachelor of Science in Economics and Mathematical Sciences (jointly administered by the Department of Mathematics and the Undergraduate Economics Program), and Bachelor of Science in Economics and Statistics (jointly administered by the Department of Statistics and the Undergraduate Economics Program).

The four major degree programs have been designed to provide students with a solid understanding of the central theories and analytical tools of the field of economics, while maintaining the flexibility necessary to meet the needs of a diversity of career paths. The four degrees produce strong analytical thinkers who are able to model and analyze complex problems. Graduates of the Undergraduate Economics Program gain employment as economic analysts in both the private and public sectors; pursue advanced professional degrees in business, law, and public policy; as well as enter into Ph.D. programs in economics, statistics, finance, and related fields.

For students who major in other academic fields, additional major programs in Economics and in Economics and Statistics and a minor degree program in Economics are available. Information about these degrees can be found following the discussions about the major curricula.

Major Degree Requirements and Sample Schedules

In addition to completing a minimum 360 units and fulfilling both the Dietrich General Education requirements and all University requirements, recipients of an undergraduate degree in economics must complete courses in mathematics, probability and statistics, writing, economic theory, and economic analysis, as well as a set of advanced electives and other specialized courses. It is important for students to realize that degree requirements are actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Following the list of requirements for each degree are sample four-year course schedules for a student pursuing an undergraduate degree in economics. As there are many different ways of completing the requirements, students are strongly encouraged to meet with an economics advisor to tailor their courses to their own particular needs. Students are responsible for ensuring that they understand all of the program requirements and that they meet the necessary conditions for graduation. When planning course schedules, students must give consideration to all prerequisite and co-requisite requirements.

In addition to meeting university and college graduation requirements, the Undergraduate Economics Program has the additional requirement: Economics courses counting towards any economics primary degree, additional major, or minor must be completed with a grade of "C" or higher.

B.A. in Economics

The B.A. in Economics provides a strong foundation in economic analysis and quantitative methods. The curriculum's breadth incorporates the study of political, historical, and social institutions so that students may use the economic toolkit to address the current challenges humanity faces. Built into the degree is the opportunity to study political, historical, cultural, and social institutions from other CMU departments; these courses are referred to as "Special Electives". The advanced data analysis component of the B.A. in Economics Curriculum pays additional attention to ordinal data and the study of surveys. The capstone of the curriculum is the Senior Project course where students use their qualitative and quantitative skills to contribute to the body of knowledge in empirical, experimental, and/or theoretical studies. Students pursuing this degree will be well-equipped to pursue graduate work (professional and academic), enter directly into the business world, or pursue public service.

B.A. in Economics Curriculum

Total Number of Units for the Major: 173/182

Mathematics Prerequisites (19 units)

Courses		Units
21-120	Differential and Integral Calculus Passing the MCS assessment test is an acceptable alternative to completing 21-120.	10
21-256	Multivariate Analysis	9

Sophomore Economics Colloquium (1 unit)

		Units
73-450	Economics Colloquium	1

Writing Requirement (9 units)

		Units
73-270	Writing for Economists	9

Economic Theory Requirements (27 units)

		Units
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9

Economic History Requirement (9 Units)

		Units
73-310	Evolution of Economic Ideas and Analysis	9

Quantitative Analysis Requirements (36 Units)

		Units
36-201	Statistical Reasoning and Practice	9
or 36-207	Probability and Statistics for Business Applications	
or 70-207	Probability and Statistics for Business Applications	
36-202	Statistical Methods	9
or 36-208	Regression Analysis	
or 70-208	Regression Analysis	
73-407	Fundamentals of Statistical Modeling	9
36-303	Sampling, Survey and Society	9

Advanced Economics Electives (36 Units)

Students must take four advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-310 Evolution of Economic Ideas and Analysis, 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium) as well as selected courses designated by the Program offered by other departments/programs. Additionally, students may work with their advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

Special Electives (27 Units)

Students must take three special elective courses in the humanities and social sciences. The complete list of courses designated as special electives is available to current students at MyTepper (<http://>

mytepper.tepper.cmu.edu). The list below is representative of the courses that qualify as "Special Electives"; this is not an exhaustive list of qualifying courses. In particular, the graduate courses from Heinz College which open to B.A. in Economics students are not presented.

Course List

Representative List of Special Elective Courses		Units
79-221	Development and Democracy in Latin America	9
79-245	Capitalism and Individualism in American Culture	9
79-246	Industrial America	9
79-266	Russian History: From Communism to Capitalism	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-300	History of American Public Policy	9
79-392	History of Modern Warfare	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
80-130	Introduction to Ethics	9
80-136	Social Structure, Public Policy & Ethics	9
80-221	Philosophy of Social Science	9
80-235	Political Philosophy	9
88-260	Organizations	9
80-305	Rational Choice	9
80-321	Causation, Law, and Social Policy	9
80-337	Philosophy, Politics & Economics	9
80-348	Health Development and Human Rights	9
84-310	International Political Economy and Organizations	9
88-365	Behavioral Economics and Public Policy	9
88-387	Social Norms and Economics	9
88-411	Rise of the Asian Economies	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9

Senior Work (9 Units; 18 Units for students working on an honors thesis in economics)

	Units
73-497 Senior Project	9
or 73-500 & 73-501 Tepper College Honors Thesis I and Tepper College Honors Thesis II	
or 66-501 & 66-502 H&SS Senior Honors Thesis I and H&SS Senior Honors Thesis II	

Sample Schedule for B.A. in Economics

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; and 2) room has been built into the schedule that would allow students to pick up additional degrees and/or study abroad. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
36-201 Statistical Reasoning and Practice	36-202 Statistical Methods	73-450 Economics Colloquium	73-407 Fundamentals of Statistical Modeling
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis**	"Special Elective"	Economics Elective
-----*	-----	-----	-----
-----	-----	-----	-----

Junior		Senior	
Fall	Spring	Fall	Spring
73-310 Evolution of Economic Ideas and Analysis	36-303 Sampling, Survey and Society	73-497 Senior Project	Economics Elective
73-270 Writing for Economists	Economics Elective	Economics Elective	----
"Special Elective"	"Special Elective"	----	----
----	----	----	----
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*In each semester, ----- represents courses that are not directly required for the major.

** While not required, 73-155 is strongly recommended.

B.S. in Economics

The B.S. in Economics provides a strong foundation in economic theory and advanced quantitative analysis. The curriculum focuses on using "real-world" data to forecast behavior and to investigate the relationships between observed phenomenon and economic models. Combining these sophisticated economic modeling data analytic skills with our wide range of upper-level economic electives provides students with a rigorous analytical foundation that will allow them to pursue any career that interests them. The capstone of the curriculum is the Senior Project course where students use their qualitative and quantitative skills to contribute to the body of knowledge in empirical, experimental, and/or theoretical studies. Students completing this degree will be well-equipped to pursue graduate work (professional and academic) or enter directly into the business world or public service.

B.S. in Economics Curriculum

Total Number of Units for the Major 156/165

Mathematics Requirement (29 Units)

	Units
21-120 Differential and Integral Calculus Passing the MCS assessment test is an acceptable alternative to completing 21-120.	10
21-256 Multivariate Analysis	9
or 21-259 Calculus in Three Dimensions	
21-122 Integration and Approximation *	10
or 21-127 Concepts of Mathematics	
or 21-257 Models and Methods for Optimization	
*Students are encouraged to meet with an economics advisor to determine which course best fits their interests	

Sophomore Colloquium (1 Unit)

	Units
73-450 Economics Colloquium	1

Quantitative Analysis Requirements (27 Units)

	Units
36-225 Introduction to Probability Theory	9
or 36-217 Probability Theory and Random Processes	
or 21-325 Probability	
73-274 Econometrics I	9
73-374 Econometrics II	9

Writing Requirement (9 Units)

	Units
73-270 Writing for Economists	9

Economic Theory Requirements (27 Units)

	Units
73-100 Principles of Economics	9
73-230 Intermediate Microeconomics	9
73-240 Intermediate Macroeconomics	9

Advanced Economics Electives (54 Units)

Students must take six advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium). For the purpose of these requirements, the Undergraduate Economics Program may also designate as advanced elective courses from other departments/programs. Additionally, students may work with their advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

Senior Work (9 Units; 18 Units for students working on an honors thesis in economics)

		Units
73-497	Senior Project	9
or 73-500 & 73-501	Tepper College Honors Thesis I and Tepper College Honors Thesis II	
or 66-501 & 66-502	H&SS Senior Honors Thesis I and H&SS Senior Honors Thesis II	

Sample Course Schedule for the B.S. in Economics

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; and 2) room has been built into the schedule that would allow students to pick up additional degrees and/or study abroad. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	73-240 Intermediate Macroeconomics
36-201 Statistical Reasoning and Practice	73-155 Legonomics: Building Blocks of Economic Analysis**	73-230 Intermediate Microeconomics	73-274 Econometrics I
73-100 Principles of Economics	-----	73-450 Economics Colloquium	Economics Elective
-----*	-----	Third Mathematics Course	-----
-----	-----	-----	-----

Junior		Senior	
Fall	Spring	Fall	Spring
73-270 Writing for Economists	Economics Elective	73-497 Senior Project	Economics Elective
73-374 Econometrics II	Economics Elective	Economics Elective	-----
Economics Elective	-----	-----	-----
-----	-----	-----	-----
-----	-----	-----	-----

*In each semester, ----- represents courses not directly required for the major.

**While not required, 73-155 is strongly recommended.

B.S. in Economics and Mathematical Sciences

The B.S. in Economics and Mathematical Sciences is a collaborative effort between the Department of Mathematical Sciences and the Undergraduate Economics Program. Combining advanced mathematics with advanced economic theory is the hallmark of this curriculum. The curriculum provides students with courses that complement and develop depth of understanding of economic theory, applied economics, and applied mathematics. This degree offers an integrated curriculum, guiding students through a program of coursework that exploits and builds upon the synergies between mathematics and economics. This degree program equips students with the mathematical tools that are essential for success in Ph.D. programs in economics; mathematics; and key functional areas of business including finance, accounting, marketing, and information systems. Students pursuing this degree will be well prepared for the beginning of their research careers in academia, government, and industry. There are a limited number of student openings in this program; interested students may apply as early as their sophomore year. The application process may include a discussion

with the Department of Mathematics's Director of Undergraduate Studies and the Undergraduate Economics Program's Executive Director; a Carnegie Mellon faculty recommendation; and a completed application submission (The application requests information about academic achievement, potential research interests, academic and/or research recognition, and meta-curricular activities. Details may be found at MyTepper (<http://mytepper.tepper.cmu.edu>)). Acceptance into the degree program is based on academic performance, rigor of coursework, and initiative while at Carnegie Mellon. In order to graduate with the B.S. in Economics and Mathematical Sciences, students must maintain a cumulative Q.P.A. of 3.33.

B.S. in Economics and Mathematical Sciences Curriculum

Total Number of Units for the Major 230

Economic Theory Requirements (27 Units)

		Units
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9

Quantitative Analysis Requirements (36 Units)

		Units
36-225	Introduction to Probability Theory	9
or 36-217	Probability Theory and Random Processes	
or 21-325	Probability	
36-226	Introduction to Statistical Inference	9
36-401	Modern Regression	9
73-374	Econometrics II	9

Mathematical Sciences Requirements (85 Units)

		Units
21-120	Differential and Integral Calculus	10
	Passing the MCS assessment test is an acceptable alternative to completing 21-120.	
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
21-228	Discrete Mathematics	9
21-241	Matrices and Linear Transformations	10
21-259	Calculus in Three Dimensions	9-10
or 21-256	Multivariate Analysis	
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9
21-355	Principles of Real Analysis I	9
21-356	Principles of Real Analysis II	9

Programming Requirement (10 Units)

		Units
15-110	Principles of Computing	10

Writing Requirement (9 Units)

		Units
73-270	Writing for Economists	9

Advanced Economic Electives (36 Units)

Students must take four advanced economics elective courses. Advanced Elective courses are those courses numbered 73-300 through 73-495, (excluding 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium) as well as courses designated by the Undergraduate Economics Program which are offered by other departments/programs. Students are encouraged to work with their advisors to structure a set of courses which meet these requirements based on their particular interests, subject to course availability.

Recommended Advanced Economics Electives:

73-310	Evolution of Economic Ideas and Analysis	9
73-315	Market Design	9
73-338	Financial Crises and Risk	9

73-347	Game Theory for Economists	9
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Mathematical Science Depth Electives (27 Units)

Students must take three advanced mathematics depth courses. Students are encouraged to work with their advisors to structure a set of courses which meet these requirements based on their particular interests, subject to course availability.

Recommended Mathematical Science Depth Electives:

21-292	Operations Research I	9
21-329	Set Theory	9
21-365	Projects in Applied Mathematics	9
21-366	Topics in Applied Mathematics	9
21-371	Functions of a Complex Variable	9
21-374	Field Theory	9
21-441	Number Theory	9
21-484	Graph Theory	9
21-499	Undergraduate Research Topic	9

Note: Only one of the following three courses may count towards the required Mathematical Sciences Depth Electives: 21-365, 21-366, or 21-499.

Sample Course Schedule for the B.S. in Economics and Mathematical Sciences

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; 2) room has built into the schedule that would allow students to pick up additional degrees and/or study abroad; and 3) the demands of this degree require students to carefully plan their degree program while keeping in mind the college-level and university-level graduation requirements. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	15-110 Principles of Computing	21-122 Integration and Approximation	21-241 Matrices and Linear Transformations
36-201 Statistical Reasoning and Practice	21-256 Multivariate Analysis	21-127 Concepts of Mathematics	36-226 Introduction to Statistical Inference
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis**	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
-----*	-----	36-225 Introduction to Probability Theory	Economics Elective
-----	-----	-----	-----

Junior		Senior	
Fall	Spring	Fall	Spring
21-260 Differential Equations	21-355 Principles of Real Analysis I	21-228 Discrete Mathematics	21-356 Principles of Real Analysis II
73-374 Econometrics II	Economics Elective	36-401 Modern Regression	-----
73-270 Writing for Economists	Economics Elective	Mathematics Elective	-----
Economics Elective	Mathematics Elective	-----	-----
Mathematics Elective	-----	-----	-----

*In each semester, ----- represents courses not directly required for the major. Please note that students pursuing the B.S. in Mathematical Sciences and Economics must fulfill the Mellon College General Education requirements and not the Dietrich College General Education requirements.

**While not required, 73-155 is strongly recommended.

B.S. in Economics and Statistics

Academic Advisor: Paige Houser
 For questions about Economics courses contact: Carol Goldberg or Kathleen Conway
 For questions about Statistics courses contact: Rebecca Nugent or Paige Houser

Office: Baker Hall 132A
 Email: acadcoord@stat.cmu.edu

The Major in Economics and Statistics provides an interdisciplinary course of study aimed at students with a strong interest in the empirical analysis of economic data. With joint curriculum from the Department of Statistics and the Undergraduate Economics Program, the major provides students with a solid foundation in the theories and methods of both fields. Students in this major are trained to advance the understanding of economic issues through the analysis, synthesis and reporting of data using the advanced empirical research methods of statistics and econometrics. Graduates are well positioned for admission to competitive graduate programs, including those in statistics, economics and management, as well as for employment in positions requiring strong analytic and conceptual skills - especially those in economics, finance, education, and public policy.

The requirements for the B.S. in Economics and Statistics are the following:

I. Prerequisites 38-39 units

1. Mathematical Foundations 38-39 units

Calculus

21-120	Differential and Integral Calculus	10
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and one of the following three:

21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
21-257	Models and Methods for Optimization	9

and one of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

Note: Passing the MSC 21-120 assessment test is an acceptable alternative to completing 21-120.

Note: Taking both 21-111 and 21-112 is equivalent to 21-120. The Mathematical Foundations total is then 48-49 units. The Economics and Statistics major would then total 201-202 units.

Linear Algebra

One of the following three courses:

21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	10
21-242	Matrix Theory	10

Note: 21-241 and 21-242 are intended only for students with a very strong mathematical background.

II. Foundations 18-27 units

2. Economics Foundations 9 units

73-100	Principles of Economics	9
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3. Statistical Foundations 9-18 units

Sequence 1 (For students beginning their freshman or sophomore year)

36-201	Statistical Reasoning and Practice	9
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and one of the following:

36-202	Statistical Methods	9
36-208	Regression Analysis	9
36-309	Experimental Design for Behavioral and Social Sciences	9

Or extra statistical elective**

*Acceptable equivalents for 36-201 are 36-207 (70-207), 36-220 and 36-247.

**Students who enter the program with 36-225/36-226 should discuss options with their advisors.

Sequence 2 (For students beginning later in their college career)

Advanced

Choose one of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9

36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9

III. Disciplinary Core 126 units

1. Economics Core 36 units

73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
73-270	Writing for Economists	9
73-374	Econometrics II	9

2. Statistics Core 36 units

36-225 Introduction to Probability Theory *# 9

and one of the following two courses:

36-226	Introduction to Statistical Inference *	9
36-326	Mathematical Statistics (Honors) *	9

and both of the following two courses:

36-401	Modern Regression *	9
36-402	Advanced Methods for Data Analysis	9

*In order to be a major in good standing, a grade of C or better is required in 36-225 (or equivalents), 36-226 or 36-326 and 36-401. Otherwise you will not be allowed to continue in the major.

#It is possible to substitute 36-217 or 21-325 for 36-225. (36-225 is the standard introduction to probability, 36-217 is tailored for engineers and computer scientists, and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.)

3. Computing 9 units

36-350	Statistical Computing *	9
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*A higher level Computer Science course approved by your Academic Advisor may be used as a substitute.

4. Advanced Electives 45 units

Students must take three advanced Economics elective courses (numbered 73-300 through 73-495, excluding 73-374, 73-407 and 73-450) and two advanced Statistics elective courses (numbered 36-303, 36-315, or 36-410 through 36-495).

Total number of units for the major 182-192 units

Total number of units for the degree 360 units

Sample Program

The following sample program illustrates one way to satisfy the requirements of the Economics and Statistics Major. Keep in mind that the program is flexible and can support other possible schedules (see footnotes below the schedule).

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	36-202 Statistical Methods	21-122 Integration and Approximation **	21-240 Matrix Algebra with Applications
36-201 Statistical Reasoning and Practice	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
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Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-402 Advanced Methods for Data Analysis	Statistics Elective	Economics Elective
36-401 Modern Regression	73-270 Writing for Economists	Economics Elective	Statistics Elective
73-374 Econometrics II	Economics Elective	-----	-----
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*In each semester, ----- represents other courses (not related to the major) which are needed in order to complete the 360 units that the degree requires.

** Students can also take 21-127 or 21-257. Students should consult with their advisor.

73-155 is not required but it is recommended by the Economics department.

Prospective PhD students might add 21-127 fall of sophomore year, replace 21-240 with 21-241, add 21-260 in spring of junior year and 21-355 in fall of senior year.

Students who elect Economics and Statistics as a second major must fulfill all Economic and Statistics degree requirements. Majors in many other programs would naturally complement a Statistics Major, including Business Administration, Social and Decision Sciences, Policy and Management, Social & Political History, and Psychology.

With respect to double-counting courses, it is departmental policy that students must have at least six courses (three Economics and three Statistics) that do not count for their primary major. If students do not have at least six, they typically take additional advanced electives.

Students are advised to begin planning their curriculum (with appropriate advisors) as soon as possible. This is particularly true if the other major has a complex set of requirements and prerequisites.

Supplemental Programs

Honors Program in Economics

Outstanding students are eligible for the honors programs in both the Tepper School of Business and the Dietrich College of Humanities and Social Sciences. For more information, consult the Dietrich Honors Program website (<http://www.cmu.edu/dietrich/undergraduate/programs/shp>).

The Tepper Senior Honors Program in Economics (<http://tepper.cmu.edu/prospective-students/undergraduate/economics/curriculum/research/senior-honors-program>) provides qualified students with the opportunity to engage in original research during their senior year at Carnegie Mellon. The primary rewards of participating in the Honors Program in Economics are three-fold. First comes the satisfaction of undertaking and completing an original piece of research. Working independently or with a faculty member to identify a research question and claim ownership of its discovery process is a rewarding experience. Second is the opportunity to challenge oneself intellectually. The third advantage is the opportunity to graduate with Tepper Honors. For many, this process of intellectual inquiry and knowledge creation is the highlight and culmination of their undergraduate academic experience.

Students are invited into the Tepper Senior Honors Program in Economics during their junior year. Invitation is based on academic achievement at Carnegie Mellon University, ability to work independently, and tenacity of spirit.

Accelerated Master's Degree Programs

Accelerated Master's Degree programs enable exceptional students to earn both an undergraduate degree and a masters degree by remaining one additional year at Carnegie Mellon. The Heinz College of Public Policy and Management offers four professional accelerated masters degree programs: a Master of Science in Arts Administration (<http://www.heinz.cmu.edu/school-of-public-policy-management/arts-management-mam>), Master of Science of Health Care and Policy Management (<http://www.heinz.cmu.edu/school-of-public-policy-management/healthcare-policy-management-hcpm>), Master of Information Systems Management (<http://www.heinz.cmu.edu/school-of-information-systems-and-management/information-systems-management-mism>), and Master of Science in Public Policy and Management (<http://www.heinz.cmu.edu/school-of-public-policy-management/public-policy-management-msppm>). The Tepper School of

Business offers one accelerated professional degree, a Master in Business Administration.

Dual Degree in Economics

A student pursuing a primary degree outside of the department may obtain a dual degree by completing all of the requirements for the B.S. in Economics or the B.S. in Economics and Statistics along with the Dietrich College general education requirements. In addition, the student's total units completed must be at least 90 units in excess of the requirement for the student's other degree(s) or at least 450 units, whichever is greater. Interested students should meet with an economics advisor.

Additional Major in Economics Curriculum

All university students are eligible to pursue an additional major in economics in conjunction with a major in any department in the university other than economics. The requirements for the Additional Major in Economics are the same as those for the B.S. in Economics, except that the Dietrich College General Education requirements are waived. In order to avoid "double counting" issues, students are encouraged to meet with an economics advisor. When courses are shared across degrees, students pursuing an Additional Major in Economics are asked to take additional advanced economics electives.

Additional Major in Economics and Statistics Curriculum

All university students are eligible to pursue a major in economics and statistics in conjunction with a major in any department in the university other than statistics or economics. The requirements for the Additional Major in Economics in Statistics are the same as those for the B.S. in Economics and Statistics, except that the Dietrich College General Education requirements are waived. In order to avoid "double counting" issues, students are encouraged to meet with an economics or statistics advisor. When courses are shared across degrees, students pursuing an Additional Major in Economics and Statistics are asked to take additional advanced economics or statistics electives.

Minor in Economics

The Minor in Economics degree program provides students with a solid understanding of economic theory and data analysis.

All university students are eligible to pursue the Minor in Economics in conjunction with a major in any other department in the university. In order to avoid "double counting" issues, students are encouraged to meet with an economics advisor. When courses are shared across degrees, students pursuing a minor in Economics are asked to take additional advanced economics electives.

All economics course counting towards the minor must be completed with a grade of "C" or higher.

Minor in Economics (Total Number of Units for the Minor: 82/91)

Mathematics Requirements (19 Units)

	Units
21-120 Differential and Integral Calculus	10
21-256 Multivariate Analysis	9

Economic Theory Requirements (18/27 Units)

	Units
73-100 Principles of Economics	9
73-230 Intermediate Microeconomics	9
73-240 Intermediate Macroeconomics *	9

*Some students may choose to focus their minor in microeconomics theory and applications. These students may elect not to take 73-240 Intermediate Macroeconomics, and instead, replace it with an additional advanced economics elective.

Quantitative Analysis Requirements (18/27 Units)

The quantitative analysis path is often determined by the major requirements. The sequence is designed to give students an understanding of probability theory, regression analysis, and quantitative economic analysis. Students are encouraged to talk with an economics advisor to determine which requirements best complement their primary fields of study.

	Units
Option One	
36-201 Statistical Reasoning and Practice	9
36-202 Statistical Methods	9
or 36-309 Experimental Design for Behavioral and Social Sciences	
73-407 Fundamentals of Statistical Modeling	9
Option Two	
70/36-207 Probability and Statistics for Business Applications	9
70/36-208 Regression Analysis	9
73-407 Fundamentals of Statistical Modeling	9
Option Three	
36-220 Engineering Statistics and Quality Control	9
73-407 Fundamentals of Statistical Modeling	9
Option Four	
36-217 Probability Theory and Random Processes	9
or 36-225 Introduction to Probability Theory	
36-202 Statistical Methods	9
or 36-309 Experimental Design for Behavioral and Social Sciences	
or 36-226 Introduction to Statistical Inference	
73-407 Fundamentals of Statistical Modeling	9
or 73-374 Econometrics II	

Advanced Economics Electives (18/27 Units)

Students must take two advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium) as well as courses designated by the program offered by other departments/programs. Additionally, students may work with their economics advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

Academic Standards and Policies

Undergraduate economics students are in the unique position of belonging to two CMU colleges, Marianna Brown Dietrich College of Humanities and Social Sciences and the Tepper School of Business. To find a detailed description of policies governing economics students, please consult the undergraduate section of MyTepper (<http://mytepper.tepper.cmu.edu>).

Faculty

LAURENCE ALES, Associate Professor of Economics - Ph.D., University of Minnesota; Carnegie Mellon, 2008-.

KATHARINE ANDERSON, Assistant Professor of Economics and Entrepreneurship - Ph.D., University of Michigan; Carnegie Mellon, 2010-.

STEPHEN M. CALABRESE, Visiting Associate Professor of Economics, Carnegie Mellon University-Qatar - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007-.

KAREN B. CLAY, Associate Professor of Economics and Public Policy, H. J. Heinz III College - Ph.D., Stanford University; Carnegie Mellon, 1998-.

ROBERT M. DAMMON, Dean; Professor of Financial Economics - Ph.D., University of Wisconsin; Carnegie Mellon, 1984-.

TIMOTHY P. DERDINGER, Assistant Professor of Economics and Strategy - Ph.D., University of Southern California; Carnegie Mellon, 2009-.

KENNETH B. DUNN, Professor of Financial Economics - Ph.D., Purdue University; Carnegie Mellon, 1979-.

DENNIS N. EPPLE, Thomas Lord University Professor of Economics - Ph.D., Princeton University; Carnegie Mellon, 1974-.

CHRISTINA FONG, Senior Research Scientist in Social and Decision Sciences, College of Humanities and Social Sciences – Ph.D., University of Massachusetts; Carnegie Mellon, 2001–.

MARTIN GAYNOR, E.J. Barone Professor of Economics and Health Policy, H. J. Heinz III College – Ph.D., Northwestern University; Carnegie Mellon, 1995–.

MARVIN GOODFRIEND, Friends of Allan Meltzer Professorship; Professor of Economics – Ph.D., Brown University; Carnegie Mellon, 2005–.

RICHARD C. GREEN, Richard M. and Margaret S. Cyert Chair; Professor of Financial Economics – Ph.D., University of Wisconsin; Carnegie Mellon, 1982–.

JOACHIM RYOHEI GROEGER, Assistant Professor of Economics – Ph.D., London School of Economics; Carnegie Mellon, 2010–.

ISA E. HAFALIR, Associate Professor of Economics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2007–.

BURTON HOLLIFIELD, PNC Professor of Finance; Professor of Financial Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1999–.

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ONUR KESTEN, Associate Professor of Economics – Ph.D., University of Rochester; Carnegie Mellon, 2005–.

YAROSLAV KRYUKOV, Assistant Professor of Economics – Ph.D., Northwestern University; Carnegie Mellon, 2008–.

ALEXEY KUSHNIR, Assistant Professor of Economics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2014–.

FINN KYDLAND, The Richard P. Simons Distinguished Professorship; University Professor of Economics; Nobel Laureate (2004) – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1977–.

REBECCA LESSEM, Assistant Professor of Economics – Ph.D., University of Wisconsin-Madison; Carnegie Mellon, 2011–.

BENNETT T. MCCALLUM, H. J. Heinz Professor of Economics – Ph.D., Rice University; Carnegie Mellon, 1981–.

ALLAN H. MELTZER, The Allan H. Meltzer University Professor of Political Economy – Ph.D., University of California, Los Angeles; Carnegie Mellon, 1957–.

ROBERT A. MILLER, Richard M. Cyert and Morris DeGroot Professor of Economics and Statistics – Ph.D., University of Chicago; Carnegie Mellon, 1982–.

JOHN R. O'BRIEN, Associate Dean, Carnegie Mellon University-Qatar; Associate Professor of Accounting and Experimental Economics – Ph.D., University of Minnesota; Carnegie Mellon, 1984–.

DUANE J. SEPPI, BNY Mellon Professor of Finance; Head, Master of Science in Computational Finance – Ph.D., University of Chicago; Carnegie Mellon, 1986–.

CHRISTOPHER SLEET, Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2005–.

FALLAW B. SOWELL, Associate Professor of Economics – Ph.D., Duke University; Carnegie Mellon, 1988–.

CHESTER S. SPATT, Pamela R. and Kenneth B. Dunn Professor of Finance – Ph.D., University of Pennsylvania; Carnegie Mellon, 1979–.

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FREDERICK H. RUETER, Adjunct Professor of Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1998–.

Visiting Faculty

SERRA BORANBAY-AKAN, Visiting Assistant Professor of Economics – Ph.D., Northwestern University; Carnegie Mellon, 2013–.

Department of English

Department of English
 Andreea Ritivoi, Department Head
 Department Office: Baker Hall 259
<http://english.cmu.edu/>

The Department of English at Carnegie Mellon involves students in the important study of reading and writing as they are embedded in historical, cultural, professional, technological, and literary practices. Working with faculty who are themselves writers, scholars, and researchers in these areas, students become effective writers and analysts of various kinds of texts in a range of media. We hold strongly to our traditional interest in print documents but extend the idea of text to include other media such as film, multimedia, and on-line texts. The types of texts that students and faculty work with include academic writing, criticism, fiction and nonfiction, professional and technical writing, argument and public advocacy, poetry, film, and even screenwriting. The English Department faculty have particular strengths in Creative Writing, in Literary and Cultural Studies, and in Rhetoric. Specialists in each area use distinctive methods of studying texts, but all share a deep commitment to working in small and intense workshops and seminars to help students learn to become experts in analyzing existing texts, and in producing original and distinctive work of their own.

The English Department offers a B.A. in English, a B.A. in Creative Writing, a B.A. in Professional Writing, and a B.S. in Technical Writing and Communication. All four majors involve the relationship of texts to contexts, and all four are structured to allow students to balance liberal and professional interests. Students in the English B.A. focus on the production and interpretation of print texts and other media in their social and cultural contexts. Students in the Creative Writing B.A. focus on analyzing and learning to produce poetic and narrative forms. Students in the Professional Writing B.A. focus on analyzing and producing non-fiction for a variety of professional contexts. Students in the Technical Writing B.S. focus on integrating writing with technical expertise in a chosen area of concentration. In addition to the four majors, the department offers a minor in English and strongly encourages non-majors in the campus community to join us in English courses, beginning with offerings at the 200-level.

English faculty and students represent a diverse but close community with a shared interest in understanding how texts are produced and understood. This interest is the foundation for the formal curriculum and also the inspiration for a range of complementary activities, including a reading series of distinguished writers of poetry, fiction, and non-fiction. English majors also have multiple opportunities to gain experience in publishing, editing, and marketing through involvement with *The Oakland Review* and The Carnegie Mellon University Press. Many of our students hold writing and editorial positions on the student newspaper, *The Tartan*, and other campus publications. We also offer a strong internship program that places student writers in media, non-profit, arts, corporate, and technical internships before they graduate. The end of every year culminates in a gala event to celebrate our students and their writing achievements in literary, academic, and professional writing. For this event, known as the Pauline Adamson Awards, we invite a well-known writer to do a public reading and then present and celebrate student writing awards in over a dozen categories, all judged anonymously by writing professionals from outside the university. Nationally prominent speakers who have participated in this event include Michael Cunningham, Jamaica Kincaid, Michael Ondaatje, Tobias Wolfe, Elizabeth Alexander, and Dennis Lehane.

Undergraduate students also have the opportunity to apply to the various Masters level graduate programs sponsored by the department. Students interested in communications careers in both the public and private sectors may receive advanced training in our Masters in Professional Writing (MAPW) program. Students who have interests in visual as well as verbal communication apply to the Masters in Design in Communication Planning and Information Design (jointly administered with the School of Design). Students with academic interests looking toward doctoral work can apply to our Masters programs in Rhetoric and in Literary and Cultural Studies to acquaint themselves with and to prepare for academic careers. The best of our Masters candidates may request consideration for the Department's Ph.D. programs in Rhetoric or in Literary and Cultural Studies and will be, in any case, well prepared for graduate work no matter where they choose to go. Upper level undergraduates interested in graduate level work should contact the English Department directly for further information and for advice on planning their junior and senior years to prepare for graduate study.

Majoring in English: The Four English Degree Options

All students who major in English choose one of the four majors offered by the department as the main focus of their studies:

- The B.A. in English
- The B.A. in Creative Writing
- The B.A. in Professional Writing
- The B.S. in Technical Writing & Communication

Other Options for English Majors

Students who wish to broaden their experience with English courses may do so by taking more than the minimum requirements for each major or by combining two of the majors within the department for a double major in English. Common combinations include Professional Writing and Creative Writing, Creative Writing and the B.A. in English, or the B.A. in English and Professional Writing. Students who are already majoring in one of the English degrees can generally add a second English major by completing additional courses. Consult the English Department and the section below on "Completing an Additional Major in English" for further detail.

All of the English majors may also be combined with majors and minors from other Carnegie Mellon departments and colleges. English Department advisors can help you to explore the available options and to choose a major or combination of programs that is appropriate for your interests and goals.

How the Curriculum is Structured

In addition to Dietrich College requirements, English majors complete 11 to 12 courses (99 to 114 units) specifically related to their chosen major within English and structured as indicated below. Please note that courses taken to fulfill requirements in other major or minor programs may not be applied to requirements for any of the English Department majors or minors.

Core Requirements for the Specific Major (7 to 9 courses, 63 to 81 units)

Complete seven to nine courses.

The Core Requirements differ for each major and are designed explicitly to provide both breadth and depth within the specific major the student has chosen.

English Electives (3 to 4 courses, 27 to 36 units)

Complete three to four elective courses.

Elective Courses for the major are designed to add breadth to each student's study within English and to provide experience with the range of approaches to reading and writing available within the department. Students in all English majors are encouraged to sample widely from the Department's offerings.

The B.A. in English

An important role of English departments has been to create interpretations of the literature of various historical periods, including the present. The B.A. in English (EBA) at Carnegie Mellon builds on, and also extends, this tradition by teaching texts as part of a complex web of historical conditions and relationships; by teaching both major literary texts and public and non-fiction documents; and by teaching film, television, and other storytelling media alongside more conventional texts.

The B.A. in English is distinctive in drawing from the artistic and research strengths of the Department's faculty in Literary and Cultural Studies, Rhetoric, and Creative Writing. Literary and Cultural Studies focuses on the way texts are formally constructed and how they function in historical and contemporary contexts. Creative Writing helps students focus on language as a tool to explore and depict experience. Rhetoric focuses on the principles through which writers construct texts and audiences respond to them. Drawing from all of these perspectives, students in the B.A. in English

learn the research skills and writing strategies to enable them to analyze the language and texts of other writers and to report their research in effective texts of their own. Such training can prepare students for graduate work in literature, cultural studies, or rhetoric, and also for careers in law, business, or government, which require similar skills in interpretation, research, and writing.

The 200-level core courses are designed to introduce students to writing in a variety of genres, to a knowledge of literary and other media forms, and to a basic theoretical knowledge of how texts are produced and interpreted. In the Interpretive Practices course, students are introduced to basic concepts, methods, and practices of literary and rhetorical approaches to texts. In the Survey of Forms course, students learn how to use language to express experience through poetic and narrative forms.

In addition to these courses, students take at least one course in rhetoric, two 300-level EBA core courses, and two 400-level seminars designed to introduce them to the functioning of texts within specific cultural and rhetorical contexts. Two of 300- and 400-level courses must feature a specific historical period, and one of these “period” courses must have a pre-1900 focus. Period study introduces students to a range of historical and cultural texts and to a range of methods for analyzing these texts in their original context and across contexts. Courses that fulfill the Rhetoric Requirement focus explicitly on language and discourse as objects of study and emphasize the relationships of language, text structure, and meaning within specific contexts.

Interpretive Practices (76-294) and Research in English (76-394) are required of students in the B.A. in English. Interpretive Practices grounds students in literary and cultural theory and trains them in writing interpretations of texts. Research in English offers training in gathering information systematically and in building arguments based on that information. Students will hone their skills in reading texts, using critical commentary, assessing print and electronic materials, and conducting interviews and surveys. They will learn how to test their hypotheses against alternatives and present their research to audiences within the discipline of English. The historical or thematic content of this course will vary from one semester to another. While 76-394 is not a pre-requisite for 400 level courses, it is strongly recommended that EBA majors take this course in their Junior year. At the advanced level EBA majors are required to take two 400-level seminars for which Interpretive Practices (76-294) is a pre-requisite.

EBA majors also complete three English Electives, one at the 200 or above level and two at the 300 or 400 level. Electives at the 200 level allow students to sample introductory courses in special topics – such as gender and media studies – within rhetorical, literary, and cultural studies, or genre courses in the novel or comedy. Electives at the 300 and 400 level encourage students to explore more advanced study in the various offerings within the department. In choosing their electives, EBA students are encouraged to sample courses from across the department.

Curriculum

In addition to satisfying all of the Dietrich College degree requirements for B.A. candidates, English B.A. majors must complete 11 courses in the following areas:

EBA Core (8 courses, 72 units)

Complete both courses:

76-26x	Survey of Forms (Nonfiction, Fiction, Poetry, or Screenwriting)	
76-294	Interpretive Practices	9

Complete six required courses.

1. Research Course (1 course, 9 units)

76-394 Research in English

2. Rhetoric Requirement (1 course, 9 units)

Complete one course from a set of varied offerings in Rhetoric as designated each term by the English Department. Rhetoric courses focus explicitly on language and discourse as objects of study and emphasize the relationships of language, text structure, and meaning within specific contexts.

3-4. 300-level Courses (2 courses, 18 units)

Complete two 300-level courses that investigate the production and interpretation of texts and other media from a variety of periods and theoretical and methodological perspectives. Course offerings that meet these requirements are advertised on a semester-by-semester basis.

For EBA majors, 76-294 Interpretive Practices is a prerequisite for these courses. Course options include but are not limited to the following:

76-321	History of the British Novel	9
76-327	Influential Women Writers	9
76-334	Literature of Wall Street	9
76-339	Topics in Film Studies	9
76-341	Gender and Sexuality in Performance	9
76-350	History of Critical Ideas: Reading and Spectatorship	9
76-3xx	300-level English Course	9

5-6. 400-level Seminar Courses (2 courses, 18 units)

Complete two 400-level seminar courses which investigate a specific topic in depth and allow students to work on a major research-based paper. Courses in this category will be advertised on a semester-by-semester basis. For EBA majors, Interpretive Practices (76-294) is a prerequisite and Research in English (76-394) is pre- or co-requisite. Among current course offerings, examples include but are not limited to the following:

76-439	Seminar in Film and Media Studies	9
76-414	Politics, Media, and Romantic Literature 1789-1830	9
76-430	Arthurian Romance and Its Modern Legacy	9
76-445	John Milton: Poetry, Paradise, and Revolution	9
76-453	Literature of Empire	9
76-4xx	400-level English course	9

“Period” Course Requirement

The period course requirement is not a separate course requirement per se but one that needs to be met through the selection of the required 300- and 400-level courses. At least two of these four required courses must be “period” courses, that is, courses that focus on texts that are connected in time and place or through common social concerns. One of these two courses must focus on a historical period prior to 1900. Courses in this category will vary from year to year and be advertised on a semester-by-semester basis. Such courses may be at either the 300 or 400 level

English Electives (3 courses, 27 units)

Complete three courses from the English Department’s offerings. One may be at the 200 level or above; the remaining two must be at the 300 or 400 level. Electives may include any courses offered by the English Department with the exception of courses designed for non-majors. Some semester offerings may include cross-listed courses from Modern Languages or History.

English B.A. Sample Curriculum

As a department, we recommend beginning the major in the sophomore year if possible. Students in Dietrich College may declare a major as early as mid-semester of the spring of their first year and begin major requirements the following fall. Interpretive Practices (76-294) should generally be taken in the sophomore year and before Research in English (76-394).

Sophomore Year	Junior Year	
	Fall	Spring
76-294 Interpretive Practices	76-26x Survey of Forms	76-3xx 300-level EBA Course*
	76-394 Research in English	76-3xx/4xx Rhetoric Course
	76-3xx/4xx Rhetoric Course	76-2xx/3xx/4xx English Elective
	76-2xx/3xx/4xx English Elective	Elective
	Elective	Elective
	Elective	

Senior Year

Fall	Spring
76-4xx 400-level Seminar**	76-4xx 400-level Seminar**
76-3xx 300-level EBA Course*	76-3xx/4xx English Elective
76-3xx/4xx English Elective	Elective
Elective	Elective
Elective	Elective

* Interpretive Practices (76-294) is a prerequisite for 300-level EBA courses
 ** Interpretive Practices (76-294) is a prerequisite and Research in English (76-394) is a pre- or co-requisite for 400-level seminars.

The B.A. in Creative Writing

Carnegie Mellon is one of a small number of English departments in the country where undergraduates can major in Creative Writing. In the Creative Writing major (CW), students develop their talents in writing fiction, poetry, screenwriting, and creative nonfiction. While studying with faculty members who are writers, Creative Writing majors read widely in literature, explore the resources of their imaginations, sharpen their critical and verbal skills, and develop a professional attitude toward their writing. Students also have the opportunity to work with other nationally known poets and fiction writers through the department's Visiting Writers series. The CW program is made up of faculty and students who have an intense commitment to their work. Students who do not exhibit a high level of commitment and promise in the introductory classes will not be encouraged to continue in the major.

Beginning with the Dietrich College requirements, the curriculum for Creative Writing majors is designed to broaden the students' intellectual backgrounds and encourage their analytical abilities. English courses beyond the Creative Writing core requirements provide additional practice in the careful reading, writing and understanding of literary texts.

Students in the Creative Writing major are required to take two of the introductory Survey of Forms courses, ideally in their sophomore year. Choices include: Survey of Forms: Poetry (76-265), Survey of Forms: Fiction (76-260), Survey of Forms: Screenwriting (76-269), and Survey of Forms: Creative Nonfiction (76-261). In order to proceed into the upper level courses in the major (and in each of the genres), students must do well in these introductory courses (receive a grade of A or B). In their junior and senior years, Creative Writing majors take four workshops in fiction, poetry, screenwriting, or nonfiction. At least two of the workshops must be taken in a single genre. In the writing workshops, students develop their critical and verbal abilities through close writing and analysis of poems, stories, and other literary forms. Their work is critiqued and evaluated by peers and the faculty. Students may write a Senior Project or Honors Thesis (if they qualify for Dietrich College honors) under the supervision of a faculty member during their senior year.

Carnegie Mellon also offers Creative Writing majors various extracurricular opportunities for professional development. For example, they may work as interns with the Carnegie Mellon University Press, which is housed in the English Department. The Press publishes scholarly works, and books of poetry and short stories by both new and established American writers. Students may help edit and submit their work for publication to *The Oakland Review*, a Carnegie Mellon University-sponsored annual journal, and *Dossier*, the literary supplement to *The Tartan* (the student newspaper). Students also have opportunities to read their works in a series of readings by student writers held in the Gladys Schmitt Creative Writing Center and to hear nationally known authors as part of the Carnegie Mellon Visiting Writers series. Additionally, the English Department (in cooperation with the Carnegie Mellon University Press) offers prizes for students each year in the writing of fiction, non-fiction, poetry and screenwriting. These include the Pauline Adamson Awards, the Academy of American Poets Prize, the Carnegie Mellon University Press Prizes in poetry and fiction, the Family Friendly Programming Forum Scholarships in Film, and the Topol Award in Creative Writing/Fiction. In addition, the Gladys Schmitt Scholarship Fund and the Gladys Schmitt Student Enhancement Fund provide support for creative writing majors to attend writing conferences and festivals.

Because the Creative Writing program provides a disciplined atmosphere in which to study and write, it appeals especially to students who are as concerned with their personal growth as with vocational goals. Nevertheless, the extracurricular writing activities and a variety of writing internships available on and off campus can provide Creative Writing majors with valuable experiences for planning their future. After graduation, many Creative Writing majors go on to graduate writing programs and to careers in teaching, publishing, public relations, advertising, TV and film, or freelance writing and editing.

Curriculum

In addition to satisfying all of the Dietrich College degree requirements for B.A. candidates, Creative Writing majors must complete 11 courses in the following areas:

Creative Writing Core (7 courses, 63 units)

Survey of Forms Courses (2 courses, 18 units):

		Units
76-260	Survey of Forms: Fiction *	9
76-261	Survey of Forms: Creative Nonfiction *	9
76-262	Survey of Forms: Nonfiction	9
76-265	Survey of Forms: Poetry *	9
76-269	Survey of Forms: Screenwriting *	9

* A student must receive a grade of A or B in the Survey of Forms class in a specific genre in order to be eligible to enroll in a workshop of that genre. A student who receives a grade of C in a Survey of Forms course may enroll in a related workshop only with the permission of the workshop professor. A student who receives a D or R in Survey of Forms may not take a workshop in that genre.

Reading in Forms (1 course, 9 units):

		Units
76-362	Reading in Forms: Non-Fiction	9
76-363	Reading in Forms: Poetry	9
76-364	Reading in Forms: Fiction	9

Four Creative Writing Workshops (4 courses, 36 units)

Complete four Creative Writing workshops, at least two in a single genre. Workshops in all genres may be taken more than once for credit.

		Units
76-365	Beginning Poetry Workshop	9
76-366	Beginning Fiction Workshop	9
76-375	Magazine Writing	9
76-460	Beginning Fiction Workshop	9
76-462	Advanced Fiction Workshop	9
76-465	Advanced Poetry Workshop	9
76-469	Advanced Screenwriting Workshop	9

English Electives (4 courses, 36 units)

Complete four additional courses from the English Department's offerings. Two of the four English Electives must be courses that are designated as fulfilling the literature requirement and focus on close reading of literary texts. Please consult the list of courses published each semester by the Department for current offerings. English Electives may include any course offered by the Department. Additionally, English Electives can include no more than one course at the 200 level. The remaining English Electives must be at the 300 or 400 level. In choosing Electives, students are encouraged to sample courses from across the Department.

Creative Writing B.A. Sample Curriculum

This plan is presented as a two-year (junior-senior) plan for completing major requirements. Its purpose is to show that this program can be completed in as few as two years, not that it should or must be. In fact, as a department, we recommend beginning the major in the sophomore year if possible. Students in Dietrich College may declare a major as early as mid-semester of the spring of their first year and begin major requirements the following fall.

Junior		Senior	
Fall	Spring	Fall	Spring
76-26x Survey of Forms	76-26x Survey of Forms	76-3xx/4xx Creative Writing Workshop	76-3xx/4xx Creative Writing Workshop
76-36x Reading in Forms	76-3xx/4xx Creative Writing Workshop	76-3xx/4xx Creative Writing Workshop	76-3xx/4xx English Elective
76-2xx/3xx/4xx English Elective	76-3xx/4xx English Elective	76-3xx/4xx English Elective	Elective
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

The B.A. in Professional Writing

Professional Writing (PW) combines a professional education with a strong foundation in rhetorical studies. The major prepares students for successful careers as writers and communications specialists in a range of fields, including but not limited to: editing and publishing, government, law, journalism, the non-profit sector, education, public and media relations, corporate communications, advocacy writing, and the arts.

The PW major includes 12 courses: 9 PW Core Requirements + 3 English Electives. The 9 Core Requirements include foundations courses in genre studies, editing, and argument, plus a cluster of advanced rhetoric and specialized writing courses, all designed to closely integrate analysis and production. Through special topics courses—journalism, web design, advocacy writing, document design for print, science writing, public relations and corporate communications, writing for multimedia—students can pursue specializations while working with faculty who are both experts and practicing professionals in these fields. PW majors also gain experience in working on team- and client-based projects and receive focused support to develop a portfolio of polished writing samples to use in applying for internships and employment. Through English Electives in Rhetoric, Creative Writing, and Literary and Cultural Studies, students gain additional practice in the careful reading, writing, and analysis of both literary and non-fictional texts and important insights into how texts function in their historical and contemporary contexts. As a capstone experience, senior PW majors have the opportunity to complete a Senior Project or, upon invitation from the college, a Senior Honors Thesis in Rhetoric or Professional Writing. PW students can also apply for research grants through the Undergraduate Research Office to work on independent research projects with faculty.

While the major appeals to students with strong professional interests, both core and elective requirements develop the broad intellectual background one expects from a university education and prepare students to either enter the workplace or pursue graduate study in fields as diverse as communications, law, business, and education. PW majors also have the opportunity to apply for the Department's accelerated MA in Professional Writing, the MAPW 4+1, which allows them to complete the degree in 2 semesters instead of the usual 3. Because the major in Professional Writing is deliberately structured as a flexible degree that allows a broad range of options, PW majors should consult closely with their English Department advisors on choosing both elective and required courses and in planning for internships and summer employment.

Various opportunities for writers to gain professional experience and accumulate material for their writing portfolios are available through campus publications, department-sponsored internships for academic credit, and writing-related employment on and off campus.

PW majors also have the option of taking writing internships for academic credit during their junior or senior year and are also strongly encouraged to seek professional internships throughout their undergraduate years and during their summers. Opportunities in public and media relations, newspaper and magazine writing, healthcare communication, publishing, technical writing, public service organizations, and writing for the web and new media illustrate both internship possibilities and the kinds of employment that Professional Writing majors have taken after graduation.

All PW students are encouraged to enroll in the English Department's 3-unit course, Professional Seminar (76-300), which meets once a week during the fall term and provides majors with the opportunity to meet and network with practicing professionals in a range of communications fields.

Curriculum

In addition to satisfying all of the Dietrich College degree requirements for B.A. candidates, Professional Writing majors must fulfill 12 requirements in the following areas:

Professional Writing Core (9 courses, 81 units)

Complete nine courses.

Foundations Courses (4 courses, 36 units):

76-26x	Survey of Forms (Nonfiction, Fiction, Poetry, or Screenwriting)	9
76-271	Introduction to Professional and Technical Writing	9
76-390	Style	9
76-373	Argument	9

Rhetoric Requirement (1 course, 9 units):

Complete one course from a set of varied offerings in Rhetoric as designated each term by the English Department. Rhetoric courses focus explicitly on language and discourse as objects of study and emphasize the relationships of language, text structure, and meaning within specific contexts. Courses include but are not limited to the following:

		Units
76-318	Communicating in the Global Marketplace	9
76-319	Environmental Rhetoric	9
76-325	Intertextuality	9
76-340	American English	9
76-351	Rhetorical Invention	9
76-355	Leadership, Dialogue, and Change	9
76-361	Digital Humanities: Corpus Rhetoric	9
76-378	Literacy: Educational Theory and Community Practice	9
76-386	Language & Culture	9
76-389	Rhetorical Grammar	9
76-396	Non-Profit Advocacy: Genres, Methods, and Issues	9
76-420	Process of Reading and Writing	9
76-425	Science in the Public Sphere	9
76-428	Visual Verbal Communication	9
76-475	Legal Rhetoric in a Global World	9
76-476	Rhetoric of Science	9
76-484	Discourse Analysis	9
76-491	Rhetorical Analysis	9

Advanced Writing/Rhetoric Courses (4 courses, 36-42 units):

Complete four courses from a set of varied offerings in Advanced Writing/Rhetoric as designated each term by the English Department. Options include all courses that fulfill the Rhetoric requirement, plus additional courses in specialized areas of professional writing. Students should select courses in consultation with their English Department advisor or the Director of Professional and Writing. Courses include but are not limited to the following:

		Units
76-301	Internship	Var.
76-302	Global Communication Center Practicum	9
76-318	Communicating in the Global Marketplace	9
76-319	Environmental Rhetoric	9
76-325	Intertextuality	9
76-340	American English	9
76-351	Rhetorical Invention	9
76-355	Leadership, Dialogue, and Change	9
76-360	Literary Journalism Workshop	9
76-361	Digital Humanities: Corpus Rhetoric	9
76-372	News Writing	9
76-375	Magazine Writing	9
76-378	Literacy: Educational Theory and Community Practice	9
76-386	Language & Culture	9
76-389	Rhetorical Grammar	9
76-391	Document & Information Design	12
76-395	Science Writing	9
76-396	Non-Profit Advocacy: Genres, Methods, and Issues	9
76-420	Process of Reading and Writing	9
76-425	Science in the Public Sphere	9
76-428	Visual Verbal Communication	9
76-472	Topics in Journalism: Multimedia Storytelling in a Digital Age	9
76-474	Software Documentation	9
76-475	Legal Rhetoric in a Global World	9
76-476	Rhetoric of Science	9
76-481	Writing for Multimedia	12
76-484	Discourse Analysis	9
76-487	Web Design	12
76-491	Rhetorical Analysis	9

76-494	Healthcare Communications	9
39-605	Engineering Design Projects	12

English Electives (3 courses, 27 units):

Complete three courses from any of English Department's offerings (exceptions include 76-270, which is designed for non-majors). One may be at the 200 level or above; the remaining two must be at the 300 or 400 level. Two must be courses designated as Text/Context Electives, which focus on the relationship between texts and their cultural and historical contexts.

Professional Writing B.A. Sample Curriculum

This plan is presented as a two-year (junior-senior) plan for completing major requirements. Its purpose is to show that this program can be completed in as few as two years, not that it should or must be. In fact, as a department, we recommend beginning the major in the sophomore year if possible. Students in Dietrich College may declare a major as early as mid-semester of the spring of their first year and begin major requirements the following fall.

Junior		Senior	
Fall	Spring	Fall	Spring
76-271 Introduction to Professional and Technical Writing	76-26x Survey of Forms	76-3xx/4xx Advanced Writing/Rhetoric Course	76-3xx/4xx Advanced Writing/Rhetoric Course
76-390 Style	76-373 Argument	76-3xx/4xx Advanced Writing/Rhetoric Course	76-3xx/4xx Advanced Writing/Rhetoric Course
76-2xx/3xx/4xx English Elective	76-3xx/4xx Rhetoric Course	76-3xx/4xx English Elective	76-3xx/4xx English Elective
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

The B.S. in Technical Writing & Communication

The B.S. in Technical Writing & Communication (TWC) is one of the oldest undergraduate technical communication degrees in the country with a history that stretches back to 1958. The degree is specifically designed to prepare students for successful careers involving scientific, technical, and computer-related communication, including writing and designing for digital media.

Today's technical communicators have the strong backgrounds in technology, communication, and design needed to enter a broad range of information-based fields, and do work that both includes and goes well beyond writing documents for print distribution. The expanding range of options includes positions that involve organizing, managing, communicating, and facilitating the use of both technical and non-technical information in a range of fields and media.

Technical communicators develop and design web sites, explain science and technology to the public, develop print and multimedia materials, develop information management systems, design and deliver corporate training, and develop support systems for consumer products ranging from software for word processing or personal finances to complex data management systems.

The B.S. in TWC recognizes the important changes taking place in communication-based careers and includes two distinctive "tracks," one in Technical Communication (TC) and one in Scientific and Medical Communication (SMC). Both tracks begin with a common core of foundation courses in print and on-line communication as well as a shared set of prerequisites in math, statistics, and computer programming. The two tracks differ in the set of theory/specialization courses beyond the core, with each track including a specialized set appropriate to its focus.

In both tracks, TWC students work on real projects for actual clients, learn group interaction and management skills, and develop a flexible repertoire of skills and strategies to keep up with advances in software and technology. Above all, they focus on developing structures and information strategies to solve a broad range of communication and information design problems.

TWC students are able to draw on exceptional resources on and off campus to enhance their education. Most obvious are the course offerings of Carnegie Institute of Technology, the Mellon College of Science, and the School of Computer Science. Additional course offerings in business, organizational behavior, policy and management, psychology, history, and design are also encouraged. As a capstone experience, Seniors have the opportunity to complete a Senior Project or, upon invitation from the college, a Senior Honors Thesis. TWC students can also apply for grants

and fellowship through the Undergraduate Research Office to work on independent research projects with faculty.

While the major appeals to students with strong professional interests, both core and elective requirements develop the broad intellectual background one expects from a university education and prepare students to either enter the workplace upon graduation or pursue graduate study in fields as diverse as communications, business, instructional design, information design, education, and science and healthcare writing.

Various opportunities for writers to gain professional experience are available through campus publications, department-sponsored internships for academic credit, and writing-related employment on and off campus. TWC students have the option of doing internships for academic credit during their junior or senior year and are encouraged to pursue a series of internships throughout their 4 years and during their summers.

All TWC students are encouraged to enroll in the English Department's 3-unit course, Professional Seminar (76-300), which meets once a week during the fall term and provides majors with the opportunity to meet and network with practicing professionals in a range of communications fields.

The Technical Communication (TC) Track

The Technical Communication track (TC) prepares students for careers in the rapidly changing areas of software and digital media. Students learn the fundamentals of visual, verbal, and on-line communication as well as the technical skills needed to design, communicate, and evaluate complex communication systems and to manage the interdisciplinary teams needed to develop them. Students become fluent in both print-based and electronic media across a variety of information genres and learn to design information for a range of specialist and non-expert audiences. The TWC/TC major can be pursued as a primary major within Dietrich College or as a secondary major for students in other Colleges with an interest in combining their specialized subject matter knowledge with strong writing and communications skills. Graduates of this track are likely to follow in the footsteps of previous TWC students from Carnegie Mellon who are currently employed as web designers, information specialists, technical writers, and information consultants in a range of technology and communication-based organizations including Salesforce.com, IBM, Oracle, Microsoft, Apple, and HP Vertica.

The Scientific and Medical Communication (SMC) Track

The Scientific and Medical Communication track (SMC) is designed for students who seek careers that focus on communication and information design problems in health, science, and medicine. It should appeal to students with interests in the health care professions, science and public policy, patient education, scientific journalism and related fields. Like the TC track, the SMC track is designed to provide both the technical and the communication skills needed to analyze and solve complex communication problems. Students learn the fundamentals of visual, verbal, and on-line communication as well as the technical skills needed to design, communicate, and evaluate complex information systems and to manage the interdisciplinary teams needed to develop them. Students become fluent in both print-based and electronic media across a variety of information genres and learn to design information for a range of specialist and non-expert audiences. The TWC/SMC major can be pursued as a primary major within Dietrich College or as a secondary major for students in other Colleges, such as MCS, with an interest in science or medicine.

Curriculum for the TWC degree

All Technical Writing & Communication majors must satisfy the Dietrich College requirements for the B.S. degree, and a set of 3 to 4 prerequisite courses in calculus, statistics, and computer science. All prerequisites should be completed by the beginning of the fall semester, junior year. Prerequisites may double count toward Dietrich College Requirements or requirements for other majors or minors.

Mathematics Prerequisite (1 course, 10 units):

Complete one of the following:	Units
21-111 Calculus I	10
21-112 Calculus II	10
21-120 Differential and Integral Calculus	10
21-127 Concepts of Mathematics	10

Statistics Prerequisite (1 course, 9 units):

36-201 Statistical Reasoning and Practice	9
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Computer Science Prerequisites (1 - 2 courses*, 10 - 22 units):

Students in the Technical Communication track must complete two required Computer Science courses: Units

15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12

Students in the Scientific and Medical Communication track complete one required Computer Science course: Units

15-110	Principles of Computing	10
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15-110 Principles of Computing is designed for students with little or no prior programming experience and is appropriate for students in both the SMC and TC tracks. 15-112 Fundamentals of Programming and Computer Science prepares students in the TC track for all other advanced Computer Science courses.

Beyond these prerequisites, students in both TC and SMC tracks take a common set of 5 TWC Core Requirements in writing, communication, and information design. To complement these foundations courses, TWC students take a set of 3 Theory/Specialization courses specific to either TC or SMC. In addition, students in the SMC track take a series of 3 courses in the natural sciences or engineering relevant to their areas of interest, while TC students take 3 electives in management, technology, and social issues.

TWC Core Requirements (5 courses, 51 units):

76-26x	Survey of Forms (Nonfiction, Fiction, Poetry, or Screenwriting)	9
76-271	Introduction to Professional and Technical Writing	9
76-390	Style	9
76-391	Document & Information Design *	12
76-487	Web Design **	12

* prerequisite = 76-271 Introduction to Professional and Technical Writing

**prerequisite = 76-271 Introduction to Professional and Technical Writing + 76-391 Document & Information Design

Theory/Specialization Courses (3 courses, 27 units):

Complete 3 courses to deepen your area of speciality and complement your chosen track (TC or SMC) in the major. One must be chosen from among courses designated as Recommended Options for TWC majors. Theory/Specialization courses, including those marked as Recommended Options, are advertised by the English Department on a semester-by-semester basis. TWC students should select courses in consultation with their faculty advisor.

Recommended courses include but are not limited to the following: Units

76-319	Environmental Rhetoric	9
76-361	Digital Humanities: Corpus Rhetoric	9
76-395	Science Writing	9
76-425	Science in the Public Sphere	9
76-428	Visual Verbal Communication	9
76-474	Software Documentation	9
76-476	Rhetoric of Science	9
76-481	Writing for Multimedia *	12
76-491	Rhetorical Analysis	9
76-494	Healthcare Communications	9

Additional Options include but are not limited to the following: Units

76-301	Internship	Var.
76-302	Global Communication Center Practicum	9
76-318	Communicating in the Global Marketplace	9
76-319	Environmental Rhetoric	9
76-325	Intertextuality	9
76-340	American English	9
76-351	Rhetorical Invention	9
76-355	Leadership, Dialogue, and Change	9
76-360	Literary Journalism Workshop	9
76-361	Digital Humanities: Corpus Rhetoric	9
76-372	News Writing	9
76-375	Magazine Writing	9
76-378	Literacy: Educational Theory and Community Practice	9
76-386	Language & Culture	9

76-389	Rhetorical Grammar	9
76-391	Document & Information Design	12
76-395	Science Writing	9
76-396	Non-Profit Advocacy: Genres, Methods, and Issues	9
76-420	Process of Reading and Writing	9
76-425	Science in the Public Sphere	9
76-428	Visual Verbal Communication	9
76-472	Topics in Journalism: Multimedia Storytelling in a Digital Age	9
76-474	Software Documentation	9
76-475	Legal Rhetoric in a Global World	9
76-476	Rhetoric of Science	9
76-481	Writing for Multimedia	12
76-484	Discourse Analysis	9
76-487	Web Design	12
76-491	Rhetorical Analysis	9
39-605	Engineering Design Projects	12

Electives (3 courses, 27 units):

TWC majors take 3 courses outside of English to deepen their area of specialty in their track. Typically, students in the SMC track select courses in the natural sciences, psychology, and social and decision sciences, or (for example) healthcare-related courses in the Heinz School. Students in the TC track typically select courses from engineering, design, HCI, computer science, math or statistics. Students should work with their faculty advisor and the Program Director to select courses that are meaningful for their track.

TWC Sample Curriculum

This plan is presented as a five-semester (spring of sophomore year through senior year) plan for completing major requirements. Its purpose is to show that this program can be completed in as few as five semesters not that it should or must be. In fact, as a department, we strongly recommend beginning the major in the fall of the sophomore year if possible. The five-semester time frame is needed because of sequencing issues related to the required core courses. The plan does not include the 4 prerequisite courses, which should be completed by the junior year.

Sophomore Year		Junior Year	
Spring	Fall	Spring	Fall
76-271 Introduction to Professional and Technical Writing*	76-391 Document & Information Design*	76-3xx/4xx Theory/Specialization Course	
76-390 Style	76-26x Survey of Forms	Technical Communication Elective	
Elective	Technical Communication Elective	Elective	
Elective	Elective	Elective	
Elective	Elective	Elective	

Senior Year	
Fall	Spring
76-487 Web Design*	76-3xx/4xx Theory/Specialization Course
76-3xx/4xx Theory/Specialization Course	Technical Communication Elective Course
Elective	Elective
Elective	Elective
Elective	Elective

* These courses must be taken in the sequence indicated. 76-271 is offered all semesters and therefore can be taken fall or spring of sophomore year. 76-271 is a prerequisite for 76-391, and 76-271 + 76-391 are the prerequisites for 76-487. 76-391 and 76-487 are offered only in the fall semesters.

Completing an Additional Major in English

Students with interests that include more than one of the department's majors have the option of completing an additional major within the department. Students may combine any of the B.A. degrees or combine the B.S. in Technical Writing and Communication with either the B.A. in English or the B.A. in Creative Writing. Students may not combine the Professional Writing and the Technical Writing & Communication majors because so many of the courses overlap.

Students majoring in two or more English Department degrees must fulfill the Core Requirements for the Major for both programs. The Survey of Forms core requirement, common to all 4 majors, needs to be taken only once but can count toward both majors. Similarly, the English Electives need to be taken only once and can count toward both majors with the understanding that a student must complete the number of English Electives required by the program with the higher number of Electives. For example, a student combining the B.A. in English with the Creative Writing major would take the 4 English Electives required for Creative Writing.

Because the Survey of Forms course and the English Electives are allowed to double count toward both majors, students who are already majoring in one of the English degrees can generally add a second major within the department by completing 6 to 8 additional courses. For example, a student who has fulfilled all 11 requirements for the BA in English can complete the additional major in Creative Writing by adding the 6 courses of the Creative Writing Core beyond the first Survey of Forms requirement: one additional Survey of Forms course, one Reading in Forms course, and 4 Writing Workshops. Because sequencing of courses can become an issue when doing multiple majors, students are strongly advised to consult closely with their English Department advisors about the sequence of their courses.

Completing a Secondary Major in English

Students in other departments who wish to complete a secondary major in the English Department should contact the Academic Coordinator in the English Department Office to file a secondary major application form and be assigned to an English Department advisor. Secondary majors in the four English degrees are required to complete all requirements for the chosen major. Additionally, courses taken to fulfill requirements within the primary major may not double count for requirements within the chosen English Department major. The only exceptions to this rule are the TC electives for the TWC/TC degree and the Natural Science and Engineering requirements for the TWC/SMC degree. In planning schedules for a secondary major, it is critically important that students consult with both departments in which they are majoring to be sure that all requirements for graduation can be met.

Minor in English

The English Department also offers minors in Creative Writing, English Studies, Professional Writing, and Technical Writing. The minors require a minimum of five courses (45 units), plus completion of (or credit for) Interpretation and Argument (76-101) or an equivalent requirement. The minors in English are available to all undergraduate students except English majors, who may not both major and minor in English.

Courses taken to fulfill requirements in other major or minor programs may not be applied to English minor requirements (and vice versa).

Courses that meet the various requirements are advertised on a semester-by-semester basis. Full descriptions are available each semester from the English Department main office. We also publish a document titled "What Counts for What for Minors," which indicates which courses offered in a given term fulfill specific requirements in each of the minor concentrations.

English Studies Minor

Complete 6 courses, including Interpretation and Argument (76-101) as a prerequisite.

		Units
76-101	Interpretation and Argument (or credit for equivalent course)	9
76-294	Interpretive Practices (prerequisite for 300- and 400- level courses)	9
76-3xx	Two 300-level courses in Literature, Cultural Studies, or Rhetoric	18

76-xxx	One additional 300/400 level seminar in Literature, Cultural Studies, or Rhetoric*	9
76-xxx	200-level or above English Elective**	9

* Note that at least some 400-level seminars have Research in English (76-394) as a pre- or co-requisite. Students planning to take a 400-level seminar to fulfill this requirement should plan to take Research in English (76-394) as one of their 300-level courses.

** The English Elective may be any course offered by the English Department.

Creative Writing Minor

Complete 6 courses, including Interpretation and Argument (76-101) as a prerequisite.

		Units
76-101	Interpretation and Argument (or credit for equivalent course)	9
76-26x	Survey of Forms	9
76-xxx	Two 300/400 level Fiction, Poetry, or Screenwriting Workshop Classes	18
76-3xx	One Reading in Forms Course	9
76-2xx	One 200-level or above English Elective	9

* A student must receive a grade of A or B in the Survey of Forms class in order to be eligible to enroll in a workshop of that genre. A student who receives a grade of C in a Survey of Forms course may enroll in a related workshop only with the permission of his or her workshop professor. A student who receives a D or R in Survey of Forms may not take a workshop in that genre.

Professional Writing Minor

Complete 6 courses, including Interpretation and Argument (76-101) as a prerequisite.

		Units
76-101	Interpretation and Argument (or credit for equivalent course)	9
76-270 or 76-271	Writing for the Professions Introduction to Professional and Technical Writing	9
76-xxx	One 300/400 level Rhetoric course*	9
76-xxx	Two 300/400 level Advanced Writing/Rhetoric courses	18
76-xxx	One 200-level or above English elective**	9

* Courses for PW minors in these areas are advertised by the English Department each semester.

** The English Elective may be any course offered by the English Department.

Technical Writing Minor

Complete 6 courses, including Interpretation and Argument (76-101) as a prerequisite.

		Units
76-101	Interpretation and Argument	9
76-270 or 76-271	Writing for the Professions Introduction to Professional and Technical Writing	9
76-xxx	One 300/400 level Rhetoric course	9
76-xxx	Two 300/400 level Advanced Writing/Rhetoric Course courses	18
76-xxx	One 200-level or above English Elective**	9

* Courses for TW minors in these areas are advertised by the English Department each semester.

** The English Elective may be any course offered by the English Department.

Senior Honors Thesis

Seniors in all four majors in the English Department who meet the necessary requirements are invited by the College of Humanities and Social Sciences (Dietrich College) to propose and complete a Senior Honors Thesis during their final year of study. The thesis may focus on research and/or original

production in any of the areas offered as a major within the Department. To qualify for the Dietrich College Honors Program, students must have a cumulative Quality Point Average of at least 3.50 in their major and 3.25 overall at the end of their junior year and be invited by Dietrich College to participate. Students then choose a thesis advisor within the Department and propose and get approval from Dietrich College for a Senior Honors Thesis. The Honors Thesis is completed over the two semesters of the senior year (9 units each semester) under the direction of the chosen advisor. By successfully completing the thesis, students earn 18 units of credit and qualify for graduation with "College Honors."

Creative Writing majors participating in the Senior Honors Thesis program may petition to have one semester of their thesis work count as one of their Workshop course requirements. Students interested in this option should contact the Director of Undergraduate Studies.

Internship Program

Qualified students in all four of the Department's degree programs have the option of doing a professional internship for academic credit during their junior or senior years. These opportunities help students explore possible writing-related careers as well as gain workplace experience. Each internship is arranged, approved, and overseen by the Department's Internship Coordinator. Particular attention is given to matching students to internship sites of specific interest to them. Students have interned in a wide variety of communications-related positions including placements at local radio, television, and print publications; museums, theaters, and cultural organizations; non-profit and public service organizations; public relations, advertising, and marketing firms; software and technology companies; new media organizations; and hospitals and healthcare communication organizations.

To be eligible for an internship, students must have a Quality Point Average of 3.0 or better and credit for at least one writing course (including Survey of Forms) beyond Interpretation and Argument (76-101). Internships generally carry 3-12 units of credit. A 9-unit internship is the standard and requires a minimum of 120-140 hours (8-10 hours per week over a 15-week term) of work at the internship site during the term. In addition, interns complete a reflective journal and a series of short research and writing assignments relevant to the specific internship. Students doing an internship for credit must be registered for the internship during the term (including summer) when they are working at the internship site. Majors in the Department may count one 9-12 unit internship for one of their degree requirements, generally an English elective.

The Accelerated MA in Professional Writing: MAPW 4+1

The MAPW 4+1 is a special program under which Carnegie Mellon students (usually majors or minors in the English department or BHA or BHS students with relevant coursework) can qualify to complete the MA in Professional Writing in 2 semesters instead of the usual 3. Students apply for admissions during their junior or senior year and, following admission and evaluation of their transcripts, may receive credit for up to four courses, or one full semester of work toward the MA requirements. The degree has a professional focus, combines intensive work in both writing and visual design, and prepares students for a range of communications careers. The coursework and career options most commonly pursued by students in the degree include

- Writing for New Media, including web design and information design
- Writing for Print Media, including Journalism
- Editing & Publishing
- Technical writing, including instructional design
- Science, Technology, and Healthcare Writing
- Public & Media Relations / Corporate Communications / Nonprofit Communication

Students interested in applying to the 4+1 program should consult the Director of the MAPW program early in their junior year for further details and advice on shaping undergraduate coursework to qualify for this option. Detailed information on the program and relevant financial aid is available at <http://english.cmu.edu/> under the tab for the MAPW.

Faculty

MARIAN AGUIAR, Associate Professor of English and Literary and Cultural Studies - Ph.D., University of Massachusetts; Carnegie Mellon, 2002-.

AMAL AL-MALKI, Associate Teaching Professor, Liberal & Social Sciences, Carnegie Mellon University-Qatar - Ph.D., University of London; Carnegie Mellon, 2003-.

JANE BERNSTEIN, Professor of English and Creative Writing - M.F.A., Columbia University; Carnegie Mellon, 1991-.

GERALD P. COSTANZO, Professor of English and Creative Writing - M.A., M.A.T., Johns Hopkins University; Carnegie Mellon, 1970-.

JAMES DANIELS, Thomas S. Baker Professor of English and Creative Writing - M.F.A., Bowling Green State University; Carnegie Mellon, 1981-.

SHARON DILWORTH, Associate Professor of English and Creative Writing - M.F.A., University of Michigan; Carnegie Mellon, 1989-.

LINDA FLOWER, Professor of English and Rhetoric - Ph.D., Rutgers University; Carnegie Mellon, 1980-.

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PAUL HOPPER, Paul Mellon Distinguished Professor Emeritus of the Humanities, Rhetoric and Linguistics - Ph.D., University of Texas; Carnegie Mellon, 1990-.

LUDMILA HYMAN, Assistant Teaching Professor, Liberal & Social Sciences, Carnegie Mellon University-Qatar - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007-.

SUGURU ISHIZAKI, Associate Professor of Rhetoric and Visual Design - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2005-.

BARBARA JOHNSTONE, Professor of Rhetoric and Linguistics - Ph.D., University of Michigan; Carnegie Mellon, 1997-.

DAVID S. KAUFER, Professor of English and Rhetoric - Ph.D., University of Wisconsin; Carnegie Mellon, 1980-.

ALAN KENNEDY, Professor of English and Literary and Cultural Studies - Ph.D., University of Edinburgh; Carnegie Mellon, 1989-.

JON KLANCHER, Associate Professor of English and Literary and Cultural Studies - Ph.D., University of California at Los Angeles; Carnegie Mellon, 1999-.

PEGGY A. KNAPP, Professor of English and Literary and Cultural Studies - Ph.D., University of Pittsburgh; Carnegie Mellon, 1970-.

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KATHLEEN NEWMAN, Associate Professor of English and Literary and Cultural Studies - Ph.D., Yale University; Carnegie Mellon, 1997-.

JOHN J. ODDO, Assistant Professor of English and Rhetoric - Ph.D., Kent State University; Carnegie Mellon, 2011-.

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ANDREEA RITIVOI, Associate Professor of English and Rhetoric - Ph.D., University of Minnesota; Carnegie Mellon, 2001-.

KAREN SCHNAKENBERG, Teaching Professor Emeritus of Rhetoric and Professional Writing - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1995-.

DAVID R. SHUMWAY, Professor of English and Literary and Cultural Studies - Ph.D., Indiana University; Carnegie Mellon, 1985-.

KRISTINA STRAUB, Professor of English and Literary and Cultural Studies; Associate Head of the English Department - Ph.D., Emory University; Carnegie Mellon, 1987-.

CHRISTOPHER WARREN, Assistant Professor of English and Literary and Cultural Studies - Ph.D., University of Oxford; Carnegie Mellon, 2010-.

NECIA WERNER, Assistant Teaching Professor - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2011-.

DANIELLE WETZEL, Associate Teaching Professor of English and Rhetoric; Director of First-Year English - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2006-.

JEFFREY WILLIAMS, Professor of English and Literary and Cultural Studies - Ph.D., Stony Brook University; Carnegie Mellon, 2004-.

JOANNA WOLFE, Teaching Professor - Ph.D., The University of Texas at Austin; Carnegie Mellon, 2001-.

JAMES WYNN, Associate Professor of English and Rhetoric - Ph.D., University of Maryland; Carnegie Mellon, 2006-.

Department of History

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Undergraduate Degree Options in the Department of History

- **The B.A./B.S. in Social & Political History**
- **The B.A. in Global Studies**
- **The B.A./B.S. in Ethics, History, and Public Policy**

The Department of History offers undergraduates a choice of three majors: the major in Social & Political History, the major in Global Studies, and the interdepartmental major in Ethics, History, and Public Policy (administered by the Philosophy Department). Specific requirements and courses for each major are detailed below.

All three History majors are grounded firmly in the liberal arts. Each has a strong interdisciplinary bent and an equally strong commitment to using knowledge of the past to illuminate present-day social, cultural, and political affairs.

In different ways, all three majors emphasize empirical research methods and conceptual analysis, and cultivate reading, research, and writing abilities central to a variety of professions. Our students develop strong analytic and writing skills; choose among diverse U.S., global, and thematic courses; learn experientially through internships and/or study abroad; and benefit from small class sizes and easy access to faculty who are internationally known for innovative historical, anthropological, and other social science approaches to investigating the past. The study of history necessarily includes diverse societies and controversial public policy issues, usefully blending liberal education with professional development.

History is also excellent preparation for leadership positions in law, business, journalism, politics, education, and government service (e.g., U.S. Foreign Service, Health & Human Services, Federal Trade Commission). The resumes of innumerable CEOs and government statesmen show how effectively the study of history serves as a foundation for preparing leaders both at home and abroad.

Having been trained to analyze subtle and complex issues, to develop breadth of understanding, to dig out information and make sense of it, and to present their findings effectively, graduates of the History Department do extremely well in many types of for-profit, non-profit, governmental, and non-governmental organizations. Because history training combines research and writing skills with analysis of social and policy trends, it also prepares graduates for journalism and other writing careers in the modern media age.

All three History degree programs combine easily with majors in Business, Economics, English, Information Systems, Modern Languages, Philosophy, Professional Writing, Social and Decision Sciences, and Statistics.

Additional Majors

The majors in Social & Political History, Global Studies, and Ethics, History, and Public Policy may be declared as additional majors in consultation with the director of each program: Professor Steven Schlossman for Social & Political History (sls@cmu.edu), Professor John Soluri for Global Studies (jsoluri@andrew.cmu.edu), and Professor Alex London (Philosophy Department; ajlondon@andrew.cmu.edu).

Interdepartmental Majors

In addition to Ethics, History, and Public Policy major, History faculty are also integral participants in two interdepartmental majors described elsewhere in this catalog: International Relations and Politics in the Institute for Politics and Strategy, and Russian Studies in the Modern Languages Department. History courses are also central to the Environmental Policy major (additional major only).

Minors

Options for pursuing a minor in Social & Political History or Anthropology are discussed below, following the sub-section on Ethics, History, and Public Policy.

Several other minors with strong History content, detailed elsewhere in the Undergraduate Catalog, can be linked with any degree. Students should contact the relevant History faculty members listed below:

- African and African American Studies: Professor Edda Fields-Black (fieldsblack@cmu.edu)
- Environmental Studies: Professor John Soluri (jsoluri@andrew.cmu.edu)
- Gender Studies: Professor Lisa Tetrault (tetrault@andrew.cmu.edu)
- Religious Studies: Professor Allyson Creasman (allysonc@andrew.cmu.edu)
- Russian Studies: Professor Wendy Goldman (goldman@andrew.cmu.edu)
- Science, Technology, and Society: Professor Jay Aronson (aronson@andrew.cmu.edu).

Research Centers

The Department of History supports two research centers to coordinate sponsored research by faculty and graduate students. Both centers welcome undergraduates to attend and participate in frequent on-campus seminars and events. These are the *Center for African American Urban Studies and the Economy (CAUSE)*, Joe W. Trotter, Director, and the *Center for History and Policy*, Steven Schlossman, Director.

The Major in Social & Political History

Director of Undergraduate Studies: Professor Steven Schlossman; sls@cmu.edu, Baker Hall 236A, 412/268-2885
 Academic Advisor: Dr. Naum Kats; kats@andrew.cmu.edu, Baker Hall 240, 412/268-2880
http://www.history.cmu.edu/undergraduate/history_major.html

Social & Political History is a research- and writing-intensive major that emphasizes analysis of change over time and in-depth understanding of the societies, cultures, economies, political systems and conflicts that have shaped our world.

Students in Social & Political History may opt for 1) a general history degree or 2) an in-depth concentration in one of seven regions of the world: Asia, Europe, United States, African Diaspora, the Middle East, Latin America and the Caribbean, or Russia and the Former Soviet States [*There is no longer a language requirement for the regional concentration in Social & Political History.*] The department offers many broad survey courses, but electives in History also often focus on areas of specialized faculty expertise, such as environment, technology, gender, culture, labor, race, science, criminal justice, education, war, public health, politics, and diplomacy.

For students interested in pursuing a professional career in History, options today include not only research and teaching (CMU history graduates have earned Ph.D. degrees at Harvard, Northwestern, and other major universities) but also expert positions in museums, archives, historic sites, the armed services, media documentaries, and other public history venues. Often, history graduates pursue post-undergraduate professional school, such as law, business administration, education, public policy, urban planning, librarianship, journalism, the ministry, or social work. Schools in these fields usually prefer students who have acquired broad perspectives on human problems in addition to specialized skills.

Curriculum

Students graduating with a primary major in Social & Political History may pursue a B.A. or B.S. degree. This program may also be taken as an additional (i.e., second) major. Requirements for both primary and additional Social & Political History majors are Global Histories (79-104), which all Dietrich College and Tepper College students must take, plus an additional 93 units that meet the requirements of either the general Social & Political History major or a U.S. or regional concentration, for a total of 102 units.

All students in the Social & Political History major are required to complete two research-training courses: Introduction to Historical Research (79-200), a 9-unit course, and the Historical Research Seminar (79-420), a 12-unit course that is regularly offered in the Fall semester of the senior year. Students must earn a final grade of "C" or better in these two courses in order to fulfill the requirements for the major.

Social & Political History Major (General)

I. Required History Courses (39 units)

79-104	Global Histories	9
79-200	Introduction to Historical Research	9
79-240	The Development of American Culture	9
79-420	Historical Research Seminar	12

II. Required Non-U.S. Survey Course (choose one -- 9 units)

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-224	Mayan America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-233	The United States and the Middle East since 1945	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-256	20th Century Germany	9
79-258	French History: From the Revolution to De Gaulle	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9

III. Social & Political History Elective Courses (54 units)

Students must complete 54 elective History units (typically 6 courses) for the general Social & Political History major. Any history courses not fulfilling another major requirement may be chosen as an elective.

Social & Political History majors have considerable flexibility in choosing their elective courses, but should consult with the Academic Advisor, Dr. Naum Kats (BH 240), or the Director of Undergraduate Studies, Dr. Steven Schlossman, in making their selections.

Social & Political History Major (General) — Sample Curriculum

Required Dietrich College General Education Course: 79-104 Global Histories (need not be completed before beginning the major).

Junior	Senior		
	Spring	Fall	Spring
79-200 Introduction to Historical Research	Non-U.S. Survey Course	79-420 Historical Research Seminar	History Elective
79-240 The Development of American Culture	History Elective	History Elective	History Elective
History Elective	History Elective	Third Course (open)	Third Course (open)
Fourth Course (open)	Fourth Course (open)	Fourth Course (open)	Fourth Course (open)
Fifth Course (open)	Fifth Course (open)	Fifth Course (open)	Fifth Course (open)

The table above represents a two-year (junior-senior) plan for completing all requirements for the Social & Political History Major (General). The purpose of this table is merely to show that the Social & Political History Major (General) can be completed in as few as two years, not that it must

be. Students may declare the major and begin course requirements as early as the start of the sophomore year and in some instances in the freshman year. Students should meet with the department's Director of Undergraduate Studies, Professor Steven Schlossman, sls@cmu.edu, for both short- and long-term course planning.

Social & Political History Major With a United States Concentration

I. Required History Courses (39 units)

79-104	Global Histories	9
79-200	Introduction to Historical Research	9
79-240	The Development of American Culture	9
79-420	Historical Research Seminar	12

II. Required Non-U.S. Survey Course (choose one -- 9 units)

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-224	Mayan America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-233	The United States and the Middle East since 1945	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-256	20th Century Germany	9
79-258	French History: From the Revolution to De Gaulle	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9

III. United States Concentration Courses (27 units)

Students must complete 27 units (typically 3 courses) for the United States concentration, selecting from the list below.

79-217	The War in Vietnam	9
79-231	American Foreign Policy: 1945-Present	9
79-233	The United States and the Middle East since 1945	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-243	The Civil War in American Memory	6
79-244	Women in American History	9
79-245	Capitalism and Individualism in American Culture	9
79-246	Industrial America	9
79-247	The Civil War Era: 1848-1877	9
79-249	20th Century U.S. History	9
79-251	India/America: Democracy, Diversity, Development	9
79-252	Recent U.S. History, 1945-Present	9

79-253	American Massacres in History and Memory	6
79-268	World War I: The Twentieth Century's First Catastrophe	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-300	History of American Public Policy	9
79-301	History of Surveillance: From the Plantation to Edward Snowden	6
79-303	Pittsburgh and the Transformation of Modern Urban America	6
79-304	African Americans in Pittsburgh	6
79-305	Moneyball Nation: Data in American Life	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-315	Hawai'i: America's Pacific Island State	9
79-318	Sustainable Social Change: History and Practice	6
79-320	Women, Politics, and Protest	9
79-324	Adolescence in the 20th and 21st Centuries	6
79-330	Medicine and Society	9
79-331	Body Politics: Women and Health in America	9
79-338	History of Education in America	9
79-339	Juvenile Delinquency and Film (1920 to "The Wire")	9
79-340	Juvenile Delinquency and Juvenile Justice	9
79-341	The Cold War in Documents and Film	9
79-343	History of American Urban Life	9
79-345	The Roots of Rock and Roll	9
79-346	American Political Humor	9
79-348	Abraham Lincoln at 200	9
79-354	Energy & Climate: History, Science, Technology, and Policy in the US 1776-2076	9
79-363	The Rise of Modern Golf, 1860 to the Present	9
79-369	Disasters in American History: Floods and Hurricanes	6
79-370	Disasters in American History (2):Epidemics & Fires	6
79-371	African American Urban History	9
79-372	Perspectives on the Urban Environment	9
79-374	American Environmental History: Critical Issues	9
79-383	Epidemics, Disease, and Public Health	9

IV. History Elective Courses (27 units)

Students must complete 27 elective History units (typically 3 courses) for the United States Concentration. Any History courses not fulfilling another major requirement may be chosen as an elective.

Social & Political History majors have considerable flexibility in choosing their elective courses, but should consult with the Academic Advisor, Dr. Naum Kats (BH 240), or the Director of Undergraduate Studies, Dr. Steven Schlossman, in making their selections.

Social & Political History Major with a United States Concentration — Sample Curriculum

Required Dietrich College General Education Course: 79-104 Global Histories (need not be completed before beginning the major).

Junior		Senior	
Fall	Spring	Fall	Spring
79-200 Introduction to Historical Research	Non-U.S. Survey	79-420 Historical Research Seminar	U.S. History Concentration Course
79-240 The Development of American Culture	U.S. History Concentration Course	U.S. History Concentration Course	History Elective
History Elective	History Elective	Third Course (open)	Third Course (open)
Fourth Course (open)	Fourth Course (open)	Fourth Course (open)	Fourth Course (open)
Fifth Course (open)	Fifth Course (open)	Fifth Course (open)	Fifth Course (open)

The table above represents a two-year (junior-senior) plan for completing all requirements for the Social & Political History Major with a concentration in U.S. history. The purpose of this table is merely to show that the Social & Political History Major with a U.S. concentration can be completed in as few as two years, not that it must be. Students may declare the major and begin course requirements as early as the start of the sophomore year and in some instances in the freshman year. Students interested in concentrating in U.S. History should meet with the Director

of Undergraduate Studies, Professor Steven Schlossman, sls@cmu.edu, for both short- and long-term course planning.

Social & Political History Major with a Non-U.S. Regional Concentration

Students may opt to concentrate on one of the following regions of the world: African Diaspora, Asia, Europe, Latin America and the Caribbean, the Middle East, or Russia and the Former Soviet States [There is no longer a language requirement for the regional concentration in Social & Political History.]

I. Required History Courses (30 units)

79-104	Global Histories	9
79-200	Introduction to Historical Research	9
79-420	Historical Research Seminar	12

II. Required Survey Courses (choose two -- 18 units)

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-224	Mayan America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-233	The United States and the Middle East since 1945	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-240	The Development of American Culture	9
79-251	India/America: Democracy, Diversity, Development	9
79-256	20th Century Germany	9
79-258	French History: From the Revolution to De Gaulle	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9

III. Regional Concentration Courses (27 units)

Students must complete 27 units (typically 3 courses) in a single area of regional concentration.

Concentration in The African Diaspora

79-222	Between Revolutions: The Development of Modern Latin America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-237	Comparative Slavery	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-291	Globalization in East African History	6
79-304	African Americans in Pittsburgh	6

79-357	History of Black American Music	6
79-371	African American Urban History	9
79-385	The Making of the African Diaspora	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9

Concentration in Asia

79-211	East Asia in the World, 1600-Present	9
79-251	India/America: Democracy, Diversity, Development	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-309	20th Century China Through Film	9
79-319	India through Film	6

Concentration in Europe

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-256	20th Century Germany	9
79-257	Germany and the Second World War	9
79-258	French History: From the Revolution to De Gaulle	9
79-259	France During World War II	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-268	World War I: The Twentieth Century's First Catastrophe	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-282	Europe and the World since 1800	9
79-323	Family, Gender, and Sexuality in European History, 500-1800	9
79-326	German History through Film	9
79-352	Christendom Divided: The Protestant and Catholic Reformation, 1450-1650	9
79-353	Religious Identities and Religious Conflicts in 19th Century Europe	9
79-362	Law and Disorder in Early Modern Europe, 1400-1800	9
79-389	Stalin and Stalinism	9

Concentration in Latin America and the Caribbean

79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-224	Mayan America	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-254	The Jewish Diaspora in Latin America	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9

Concentration in the Middle East

79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-233	The United States and the Middle East since 1945	9
79-307	Religion and Politics in the Middle East	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9

79-398	Documenting the 1967 Arab-Israeli War	9
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Concentration in Russia and the Former Soviet States

79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-389	Stalin and Stalinism	9

IV. History Elective Courses (27 units)

Students must complete 27 elective History units (typically 3 courses) for the regional concentration. Any History courses not fulfilling another major requirement may be chosen as an elective.

Social & Political History majors have considerable flexibility in choosing their elective courses, but should consult with the Academic Advisor, Dr. Naum Kats (BH 240), or the Director of Undergraduate Studies, Dr. Steven Schlossman, in making their selections.

Social & Political History Major with a Regional Concentration — Sample Curriculum

Required Dietrich College General Education Course: 79-104 Global Histories (need not be completed before beginning the major).

Junior		Senior	
Fall	Spring	Fall	Spring
79-200 Introduction to Historical Research	Regional Concentration Course	79-420 Historical Research Seminar	Regional Concentration Course
Required Survey Course	Required Survey Course	Regional Concentration Course	History Elective
History Elective	History Elective	Third Course (open)	Third Course (open)
Fourth Course (open)	Fourth Course (open)	Fourth Course (open)	Fifth Course (open)
Fifth Course (open)	Fifth Course (open)	Fifth Course (open)	Fourth Course (open)

The table above represents a two-year (junior-senior) plan for completing all requirements for the Social & Political History Major with a Regional Concentration. The purpose of this table is merely to show that the Social & Political History Major with a Regional Concentration can be completed in as few as two years, not that it must be. Students may declare the major and begin course requirements as early as the start of the sophomore year and in some instances in the freshman year. Students should meet with the Director of Undergraduate Studies, Professor Steven Schlossman, sls@cmu.edu, for both short- and long-term course planning.

Additional Major in Social & Political History

The Social & Political History Major (general or with any concentration) may be scheduled as an additional major in consultation with the Director of Undergraduate Studies, Professor Steven Schlossman, sls@cmu.edu.

Bachelor of Science Option

Students may elect to earn a Bachelor of Science rather than a Bachelor of Arts degree by completing two courses from the list below, or by petitioning the Director of Undergraduate Studies, Professor Steven Schlossman, sls@cmu.edu to accept equivalent courses as substitutions.

21-257	Models and Methods for Optimization	9
36-202	Statistical Methods or	9
36-208	Regression Analysis	9
36-207	Probability and Statistics for Business Applications	9
36-303	Sampling, Survey and Society	9
36-309	Experimental Design for Behavioral and Social Sciences	9
80-305	Rational Choice	9
88-251	Empirical Research Methods	9

The Major in Global Studies

Director: Professor John Soluri; jsoluri@andrew.cmu.edu, Baker Hall 363, 412-268-7122
 Academic Program Manager: Emily Half; ehalf@andrew.cmu.edu, Baker Hall A60C, 412-268-7082
<http://www.cmu.edu/hss/globalstudies>

The Department of History offers the major in Global Studies, an interdisciplinary major designed for students interested in humanistic approaches to understanding past and present processes of globalization. Participating faculty in the departments of History, Modern Languages, and English conduct research in Africa, Asia, Europe, Latin America, the Middle East, and the Pacific. The rigorous yet flexible Global Studies curriculum combines anthropology, history, literary and cultural studies, and advanced language training in order to help students make sense of complex interactions among global processes, regional and local cultures, and societal structures. Global Studies majors develop a broad understanding of their prospects and responsibilities as citizens of the world confronting challenging contemporary problems.

There are three required courses for the major: the general education course Global Histories (79-104), Introduction to Global Studies (79-275), and Advanced Seminar in Global Studies (79-400). Majors also choose among several courses focused on theory, research methods, transnational histories, and regional/national histories and cultures. Demonstrating intermediate to advanced level proficiency in a language other than English is a crucial component of the major in Global Studies.

In addition to coursework at Carnegie Mellon, Global Studies majors are encouraged to incorporate a semester of study abroad into their course of study in order to immerse themselves in a society different from their own with unfamiliar cultural practices, language, and history. Global Studies majors may also enroll in 79-506 Global Studies Internship, a course that enables them to earn credit while gaining first-hand experience working with Pittsburgh-based organizations that work across borders.

Majors should consult frequently with the program's academic program manager and with participating faculty who will help students to craft a coherent course of study on specific topics and/or regions that may lead to the capstone research project (79-400 Advanced Seminar in Global Studies) or a Dietrich College senior honors thesis (<http://hss.cmu.edu/seniorhonorsprogram.html>). Program faculty and the academic program manager will also work with students to connect their academic interests and their participation in student organizations and/or organizations based in Pittsburgh with transnational reach.

Curriculum

Students graduating with a primary major in Global Studies receive a Bachelor of Arts degree. Global Studies may also be taken as an additional (e.g., second) major. Required courses include 79-104 plus 93 additional units (including 79-275 and 79-400) and proficiency in a modern language other than English. Students may double count a maximum of two courses taken for the Global Studies major that are also being used to fulfill the requirements of other majors and programs. Students should consult with the Global Studies academic program manager (see above) about new courses and study abroad courses that may be approved for students pursuing the major in Global Studies.

I. Required General Education Course (9 units)

79-104	Global Histories	9
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II. Global Studies Introductory Course (9 units)

Students must earn a final grade of "C" or better for the course to count toward the major.

79-275	Introduction to Global Studies	9
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III. Language Requirement

Demonstrating intermediate to advanced level proficiency in a language other than English is a crucial component of the major in Global Studies. Normally this requirement can be satisfied by successfully completing a course conducted in the second language at the 300 level or above for French, German, Italian, or Spanish, or the fourth semester (Intermediate II) level or above for Arabic, Chinese, Japanese, or Russian. Comparable proficiency for other languages can be considered. Additional advanced cultural, historical, and literary study in the second language is strongly recommended. Courses in a language other than English may also be counted as Global Studies transnational, global, or regional courses or Global Studies electives as appropriate.

IV. Theoretical and Topical Core Courses (18 units)

To gain a solid foundation in the theories, methods, and analytical topics underpinning the major in Global Studies, students select 18 units (typically two classes) from the core courses listed below. Students must earn a final grade of "C" or better in these courses to fulfill the theoretical and topical core course requirement.

76-453	Literature of Empire	9
76-497	Culture: Interdisciplinary Approaches	9

79-200	Introduction to Historical Research	9
79-278	Rights to Representation: Indigenous People and their Media	9
79-297	Dilemmas and Controversies in Anthropology	9
79-314	The Politics and Culture of Memory	9
79-317	Art, Anthropology, and Empire	9
79-318	Sustainable Social Change: History and Practice	6
79-332	Medical Anthropology	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-376	Doing Transnational History	9
79-377	Food, Culture, and Power: A History of Eating	9
79-380	Ethnographic Methods	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9

V. Transnational, Global, and Regional Courses (27 units)

To gain insight into how complex transnational and global processes shape and are affected by local, national, and regional dynamics, students will select 27 units (typically three courses) from any subcategories below.

Transnational and Global Courses

76-322	Global Masala: South Asians in the Diaspora	9
76-353	Global Studies	9
76-440	Postcolonial Theory: Diaspora and Transnationalism	9
76-448	The Global Renaissance	9
79-224	Mayan America	9
79-233	The United States and the Middle East since 1945	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-254	The Jewish Diaspora in Latin America	9
79-276	Beyond the Border	6
79-282	Europe and the World since 1800	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-289	Animal Planet: An Environmental History of People and Animals	6
79-295	Race Relations in the Atlantic World	9
79-299	Trafficking Persons: Children in a Global Context	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-312	International Human Rights Institutions in Theory and Practice	6
79-342	Introduction to Science and Technology Studies	9
79-383	Epidemics, Disease, and Public Health	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
79-385	The Making of the African Diaspora	9
80-348	Health Development and Human Rights	9
80-447	Global Justice	9
82-304	The Francophone World	9
82-345	Introduction to Hispanic Literary and Cultural Studies	9
84-326	Theories of International Relations	9

Regional Courses

Africa:		
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-291	Globalization in East African History	6
79-386	Entrepreneurs in Africa, Past, Present and Future	9
Eastern and Southern Asia and the Pacific:		
76-354	South Asian Literature	9
79-211	East Asia in the World, 1600-Present	9
79-264	Tibet in History and Imagination	9
82-431	China and the West	9

88-411	Rise of the Asian Economies	9	79-301	History of Surveillance: From the Plantation to Edward Snowden	6
Europe:			79-330	Medicine and Society	9
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9	79-349	The Holocaust in Historical Perspective	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9	79-506	Global Studies Internship	9
79-205	20th Century Europe	9	80-244	Environmental Ethics	9
79-207	Development of European Culture	9	80-247	Ethics and Global Economics	9
79-268	World War I: The Twentieth Century's First Catastrophe	9	80-335	Deliberative Democracy: Theory and Practice	9
79-323	Family, Gender, and Sexuality in European History, 500-1800	9	80-344	Management, Environment, and Ethics	9
79-353	Religious Identities and Religious Conflicts in 19th Century Europe	9	82-215	Introduction to Modern Arabic Literature and Culture	Var.
82-320	Contemporary Society in Germany, Austria and Switzerland	9	82-311	Arabic Language and Culture I	9
82-323	Germany, Austria and Switzerland in the 20th Century	9	82-312	Arabic Language and Culture II	9
82-415	Topics in French and Francophone Studies	9	82-358	Literacies Across Language and Culture	9
82-416	Topics in French and Francophone Studies	9	82-541	Special Topics: Hispanic Studies	Var.
82-441	Studies in Peninsular Literature and Culture	9	84-275	Comparative Politics	9
The Middle East:			84-310	International Political Economy and Organizations	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9	84-362	Diplomacy and Statecraft	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9	88-410	The Global Economy: A User's Guide	9
79-307	Religion and Politics in the Middle East	9	88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
79-398	Documenting the 1967 Arab-Israeli War	9			
82-300	Topics in Cross-Cultural Studies	9	<u>Nation-based Courses</u>		
The Americas:			76-337	Intro to Ethnic American Studies	9
79-221	Development and Democracy in Latin America	9	79-231	American Foreign Policy: 1945-Present	9
79-222	Between Revolutions: The Development of Modern Latin America	9	79-315	Hawai'i: America's Pacific Island State	9
79-223	Mexico: From the Aztec Empire to the Drug War	9	79-320	Women, Politics, and Protest	9
79-235	Caribbean Cultures	9	79-331	Body Politics: Women and Health in America	9
82-343	Latin America: Language and Culture	9	82-344	U.S. Latinos: Language and Culture	9
82-451	Studies in Latin American Literature and Culture	9	79-261	Chinese Culture and Society	9
82-455	Topics in Hispanic Studies	9	79-262	Modern China	9
82-456	Topics in Hispanic Studies	9	82-333	Introduction to Chinese Language and Culture	Var.
(27 units)VI. Elective Courses			82-433	Topics in Contemporary Culture of China	9
Students are required to take an additional 27 units (typically 3 courses) of electives, selected from one or both of the subcategories below. Category IV and V courses listed above that are not used to fulfill those requirements may be counted as electives in addition to the courses listed below.			82-434	Studies in Chinese Traditions	9
Those students who wish to pursue an optional Global Studies Senior Thesis (9 units) as one of their electives may do so by arrangement with Global Studies faculty; the thesis will often involve work in a language other than English. This option is not to be confused with the two-semester Dietrich College Senior Honors Thesis, for graduating with college-level honors.			82-440	Studies in Chinese Literature & Culture	9
Global Studies offers students the opportunity to gain credit for a 9 unit elective while gaining first-hand experience interning with Pittsburgh-based organizations that work across borders. 79-506 Global Studies Internship is offered every semester and students should register for the course after consulting with the academic advisor and faculty director. The faculty director will assist students with matching their interests to local organizations and identifying an on-site supervisor available to collaborate in the ongoing and final evaluation of the student's work.			79-258	French History: From the Revolution to De Gaulle	9
<u>Thematic Courses</u>			79-259	France During World War II	9
70-365	International Trade and International Law	9	82-303	Introduction to French Culture	9
76-241	Introduction to Gender Studies	9	82-305	French in its Social Contexts	9
76-318	Communicating in the Global Marketplace	9	79-256	20th Century Germany	9
76-386	Language & Culture	9	79-257	Germany and the Second World War	9
76-450	Literary and Cultural Theory: Law, Culture, and the Humanities	9	79-326	German History through Film	9
79-201	Introduction to Anthropology	9	82-327	The Emergence of the German Speaking World	9
79-281	Introduction to Religion	9	82-425	Topics in German Literature and Culture	9
79-296	Perspectives on Social Protest	9	82-427	Nazi and Resistance Culture	9
79-298	Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal	6	82-428	History of German Film	9
			79-319	India through Film	6
			79-255	Irish History	6
			82-361	Italian Language and Culture I	9
			82-362	Italian Language and Culture II	9
			82-273	Introduction to Japanese Language and Culture	9
			82-278	Japanese Film and Literature: The Art of Storytelling	9
			82-473	Topics in Japanese Studies	9
			82-474	Topics in Japanese Studies	9
			82-253	Korean Culture Through Film	9
			82-254	World of Korea, Then and Now	9
			79-265	Russian History: From the First to the Last Tsar	9
			79-266	Russian History: From Communism to Capitalism	9
			79-267	The Soviet Union in World War II: Military, Political, and Social History	9
			79-389	Stalin and Stalinism	9
			82-293	Introduction to Russian Culture	9
			82-294	Topics in Russian Language and Culture	9
			79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
			82-342	Spain: Language and Culture	9

VII. Senior Capstone Course (12 units)

The research seminar is the capstone course for Global Studies majors and is designed to give students the chance to define and carry out a research project of personal interest. Students are strongly encouraged to incorporate their prior coursework (including foreign language training), study abroad or internships into their research. Students must earn a final grade of "C" or better for the course to count toward the major.

79-400

Advanced Seminar in Global Studies

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Global Studies Major — Sample Curriculum

This sample curriculum represents a plan for completing the requirements for the Global Studies major. Global Studies students are encouraged to spend a semester abroad and the plan below demonstrates that study abroad fits well into the curriculum. Like most majors in the Dietrich College, the Global Studies major can be completed in as few as two years of undergraduate study. Students may declare the Global Studies major and take appropriate courses as early as the second semester of the freshman year and as late as the junior year, and should consult frequently with the Global Studies academic program manager (see above) about their course of study in Pittsburgh and possibly abroad.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
79-104 Global Histories	79-275 Introduction to Global Studies	GS Theoretical & Topical Core Course	GS Theoretical & Topical Core Course
76-101 Interpretation and Argument	36-201 Statistical Reasoning and Practice	GS Transnational, Global, Regional Course	GS Transnational, Global, Regional Course
Freshman Seminar	Language Course or Gen Ed	Language Course or Elective	Language Course or Elective
Language Course or Gen Ed	Fourth Course (open)	Fourth Course (open)	Fourth Course (open)
Fifth Course (open)	Fifth Course (open)	Fifth Course (open)	Fifth Course (open)
99-101 Computing @ Carnegie Mellon			

Junior		Senior	
Fall	Spring	Fall	Spring
GS Transnational, Global, Regional Course	STUDY ABROAD*	66-501 H&SS Senior Honors Thesis I**	66-502 H&SS Senior Honors Thesis II**
GS Elective	GS Elective	Language Course or Elective	79-400 Advanced Seminar in Global Studies
Language Course or Elective	GS Elective	Third Course (open)	Language Course or Elective
Fourth Course (open)	Language Course or Elective	Fourth Course (open)	Third Course (open)
Fifth Course (open)	Fourth Course (open)	Fifth Course (open)	Fourth Course (open)
	Fifth Course (open)		

*Spring semester of the junior year is a popular semester for study abroad. However, Global Studies majors may instead choose to study abroad in spring of sophomore year, fall of junior year, or fall of senior year. Students should discuss study abroad and curricular planning with the academic program manager.

**Students are not required to complete a college honors thesis. However, many Global Studies majors choose to apply for the senior honors thesis program. Students who do not pursue a senior honors thesis should select an elective in its place.

Additional Major

Global Studies may be elected as a primary or an additional major; the requirements for each are the same. Contact the academic program manager (see contact information above) to elect the additional major.

The Major in Ethics, History, and Public Policy

Alex John London, Director
Office: Baker Hall 150A
Email: ajlondon@andrew.cmu.edu

<http://www.cmu.edu/hss/ehpp/>

The B.A./B.S. in Ethics, History, and Public Policy is an interdepartmental major offered jointly by the Departments of History and Philosophy. It prepares students for leadership positions by providing them with a rigorous, interdisciplinary humanistic and social-scientific education. It also serves as an excellent springboard for graduate study in a wide variety of disciplines such as law, public policy, ethics, and advocacy. The program focuses equally on the historical understanding of how modern-day problems have evolved, and the importance of developing clear criteria for ethical decision-making. The capstone project course provides students with the opportunity to engage with real-world public policy challenges using the methods, theories, and knowledge that they have gained through the major. Offered jointly by the departments of History and Philosophy, the B.A./B.S. in EHPP encourages specialization, internship experiences, and research in a wide range of policy areas.

Curriculum

Students graduating with a primary major in Ethics, History, and Public Policy may elect to receive either a Bachelor of Arts or a Bachelor of Science Degree (additional requirements apply; see below). Basic requirements include 120 units encompassing 9 units in Economics, 36 units in History, 36 units in Philosophy, 27 units of elective courses, and a 12-unit senior capstone course. This program may also be taken as an additional (e.g., second) major.

I. Economics Requirement

9 units

Choose one of the following:

73-100 Principles of Economics 9

88-220 Policy Analysis I 9

3

II. History Core

36 units

Choose one 9-unit course from each category below:

Policy History (9 units)

79-300 History of American Public Policy 9

U.S. History (9 units)

79-240 The Development of American Culture 9

79-249 20th Century U.S. History 9

Non-U.S. History (9 units)

79-202 Flesh and Spirit: Early Modern Europe, 1400-1750 9

79-203 Social and Political Change in 20th Century Central and Eastern Europe 9

79-205 20th Century Europe 9

79-207 Development of European Culture 9

79-222 Between Revolutions: The Development of Modern Latin America 9

79-223 Mexico: From the Aztec Empire to the Drug War 9

79-226 African History: Earliest Times to 1780 9

79-227 African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid 9

79-229 Origins of the Arab-Israeli Conflict, 1880-1948 9

79-230 Arab-Israeli Conflict and Peace Process since 1948 9

79-237 Comparative Slavery 9

79-251 India/America: Democracy, Diversity, Development 9

79-261 Chinese Culture and Society 9

79-262 Modern China 9

79-264 Tibet in History and Imagination 9

79-265 Russian History: From the First to the Last Tsar 9

79-266 Russian History: From Communism to Capitalism 9

79-307 Religion and Politics in the Middle East 9

Historical Methods and Approaches (9 units)

79-200 Introduction to Historical Research 9

III. Philosophy Core 36 units

Choose one 9-unit course from each category below. No more than 18 units at the 100 level may be counted toward this requirement.

Ethics (9 units)

80-130 Introduction to Ethics 9

80-230 Ethical Theory 9

Political Philosophy (9 units)

80-135 Introduction to Political Philosophy 9

80-235 Political Philosophy 9

Foundations of Social Science (9 units)

80-221 Philosophy of Social Science 9

80-321 Causation, Law, and Social Policy 9

80-324 Philosophy of Economics 9

80-337 Philosophy, Politics & Economics 9

Applied Philosophy (9 units)

80-136 Social Structure, Public Policy & Ethics 9

80-244 Environmental Ethics 9

80-245 Medical Ethics 9

80-247 Ethics and Global Economics 9

80-335 Deliberative Democracy: Theory and Practice 9

80-348 Health Development and Human Rights 9

80-447 Global Justice 9

IV. Senior Capstone Project Course 12 units

79-449 EHPP Project Course [cross-listed] 12

80-449 EHPP Project Course 12

The Ethics, History and Public Policy Project Course is required for the Ethics, History and Public Policy major and is taken in the fall semester of the senior year. In this capstone course, Ethics, History and Public Policy majors carry out a collaborative research project that examines a compelling current policy issue that can be illuminated with historical research and philosophical and policy analysis. The students develop an original research report based on both archival and contemporary policy analysis and they present their results to a client organization in the community.

V. Elective Courses 27 units

Choose any three courses from any category or categories shown below.

Engineering and Public Policy (some courses have prerequisites; see EPP catalog listing)

19-424 Energy and the Environment 9

19-426 Environmental Decision Making 9

19-448 Science, Technology & Ethics 9

Business

70-311 Organizational Behavior 9

70-321 Negotiation and Conflict Resolution 9

70-332 Business, Society and Ethics 9

70-364 Business Law 9

70-365 International Trade and International Law 9

70-430 International Management 9

Economics (some courses have prerequisites; see Economics catalog listing)

73-148 Environmental Economics 9

73-310 Evolution of Economic Ideas and Analysis 9

73-352 Public Economics 9

73-358 Economics of the Environment and Natural Resources 9

73-359 Benefit-Cost Analysis 9

73-365 Firms, Market Structures, and Strategy 9

73-372 International Money and Finance 9

73-375 History of Money and Monetary Policy 9

73-408 Law and Economics 9

73-476 American Economic History 9

English

76-492 Rhetoric of Public Policy 9

History

Courses from the EHPP History Core (above) may be taken as electives only if they are not being used to fulfill the core requirement. Double counting is not permitted.

79-217 The War in Vietnam 9

79-221 Development and Democracy in Latin America 9

79-231 American Foreign Policy: 1945-Present 9

79-233 The United States and the Middle East since 1945 9

79-242 African American History: Reconstruction to the Present 9

79-253 American Massacres in History and Memory 6

79-267 The Soviet Union in World War II: Military, Political, and Social History 9

79-288 Bananas, Baseball, and Borders: Latin America and the United States 9

79-296 Perspectives on Social Protest 9

79-298 Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal 6

79-299 Trafficking Persons: Children in a Global Context 9

79-301 History of Surveillance: From the Plantation to Edward Snowden 6

79-302 Drone Warfare: Ethics, Law, Politics, History, and Strategy 6

79-303 Pittsburgh and the Transformation of Modern Urban America 6

79-305 Moneyball Nation: Data in American Life 9

79-310 From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present 9

79-312 International Human Rights Institutions in Theory and Practice 6

79-320 Women, Politics, and Protest 9

79-325 U.S. Gay and Lesbian History 6

79-331 Body Politics: Women and Health in America 9

79-338 History of Education in America 9

79-339 Juvenile Delinquency and Film (1920 to "The Wire") 9

79-340 Juvenile Delinquency and Juvenile Justice 9

79-342 Introduction to Science and Technology Studies 9

79-349 The Holocaust in Historical Perspective 9

79-355 Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective 9

79-359 Terrorism and U.S. National Security 6

79-371 African American Urban History 9

79-374 American Environmental History: Critical Issues 9

79-381 Energy and Empire: How Fossil Fuels Changed the World 9

79-383 Epidemics, Disease, and Public Health 9

79-384 Garbage Gone Global: Managing Waste in an Age of Mass Consumption 9

79-389 Stalin and Stalinism 9

Philosophy

Courses from the EHPP Philosophy Core (above) may be taken as electives only if they are not being used to fulfill the core requirement. Double counting is not permitted.

80-256 Modern Moral Philosophy 9

80-305 Rational Choice 9

80-405 Game Theory 9

Institute for Politics and Strategy

84-310 International Political Economy and Organizations 9

84-380 Grand Strategy in the United States 9

84-393 Legislative Decision Making: U.S. Congress 9

84-402 Judicial Politics and Behavior 9

Social and Decision Sciences

88-223	Decision Analysis and Decision Support Systems	9	79-207	Development of European Culture	9
88-281	Topics in Law: 1st Amendment	9	79-221	Development and Democracy in Latin America	9
88-343	Economics of Technological Change	9	79-222	Between Revolutions: The Development of Modern Latin America	9
88-345	Perspectives on Industrial Research and Development	9	79-223	Mexico: From the Aztec Empire to the Drug War	9
88-347	Complex Technological Systems: Past, Present, and Future	9	79-224	Mayan America	9
88-371	Entrepreneurship, Regulation and Technological Change	9	79-225	West African History in Film	9
88-387	Social Norms and Economics	9	79-226	African History: Earliest Times to 1780	9
88-423	Institutions, Entrepreneurship, and Innovation	9	79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
88-444	Public Policy and Regulation	9	79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
			79-230	Arab-Israeli Conflict and Peace Process since 1948	9

VI. Bachelor of Science Option

Students may elect to earn a Bachelor of Science rather than a Bachelor of Arts degree by completing two courses from the list below, or by petitioning the Director of EHPP to accept equivalent courses as substitutions.

21-257	Models and Methods for Optimization	9
36-202	Statistical Methods	9
or 36-208	Regression Analysis	
36-207	Probability and Statistics for Business Applications	9
36-303	Sampling, Survey and Society	9
36-309	Experimental Design for Behavioral and Social Sciences	9
80-305	Rational Choice	9
88-251	Empirical Research Methods	9

Additional Major

The B.A./B.S. in Ethics, History, and Public Policy may be scheduled as an additional major in consultation with the Director of Ethics, History, and Public Policy, Professor Alex John London, ajlondon@andrew.cmu.edu.

Ethics, History, and Public Policy Sample Curriculum

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
Core requirement in Economics	Core requirement in History or Philosophy	Capstone Course	EHPP Elective Course
Core requirement in History or Philosophy	Core requirement in History or Philosophy	EHPP Elective Course	Second Course (open)
Core requirement in History or Philosophy	Core requirement in History or Philosophy	EHPP Elective Course	Third Course (open)
Core requirement in History or Philosophy	Core requirement in History or Philosophy	Fourth Course (open)	Fourth Course (open)
Core requirement in History or Philosophy	Fifth Course (open)	Fifth Course (open)	Fifth Course (open)

The above sample program is presented as a two-year (junior-senior year) plan for completing EHPP major requirements. Its purpose is to show that this program can be completed in as few as two years; not that it must be. Students may enter the EHPP major, and begin major course requirements, as early as the start of the sophomore year, or even in the first year. Students should consult their advisor when planning their program.

The Minor in Social & Political History

Director of Undergraduate Studies: Professor Steven Schlossman; sls@cmu.edu, Baker Hall 236A, 412/268-2885
 Academic Advisor: Dr. Naum Kats; kats@andrew.cmu.edu, Baker Hall 240, 412/268-2880
http://www.history.cmu.edu/undergraduate/history_major.html

The minor in Social & Political History involves a minimum of 54 units of History course work.

Curriculum (54 units)

I. Required History Survey Courses (choose two -- 18 units)

Students must complete 18 units (typically 2 courses) from the following list of survey courses:

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9

79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-224	Mayan America	9
79-225	West African History in Film	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-231	American Foreign Policy: 1945-Present	9
79-233	The United States and the Middle East since 1945	9
79-235	Caribbean Cultures	9
79-237	Comparative Slavery	9
79-240	The Development of American Culture	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-245	Capitalism and Individualism in American Culture	9
79-251	India/America: Democracy, Diversity, Development	9
79-252	Recent U.S. History, 1945-Present	9
79-256	20th Century Germany	9
79-258	French History: From the Revolution to De Gaulle	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-272	Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9

II. Elective courses for the Minor in Social & Political History (36 units)

Students must complete 36 elective History units (typically 4 courses). Social & Political History minors have considerable flexibility in choosing their elective courses, but should feel free to consult with the Director of Undergraduate Studies in making their selections.

The Minor in Anthropology

Faculty Advisor: Judith Schachter; jm1e@andrew.cmu.edu (judithm@cmu.edu), Baker Hall 242D, 412-268-3239
 Academic Advisor: Emily Half; ehalf@andrew.cmu.edu, Baker Hall A60C, 412-268-7082

The Minor in Anthropology is offered by the Department of History to train students in ethnographic methods and in theoretical understandings of culture. Students examine the evolution, depth, and complexities of ethnography, and explore notions of "culture" in diverse settings, over time and across space. In today's world, students are increasingly aware of the importance of developing a sophisticated approach to culture and its articulation with changes in the domains of the arts, technology, economics, and politics. The Minor in Anthropology, which may be taken alone but especially complements the majors in Global Studies and in Social & Political History, provides students with the tools to link artistic practices to various aspects of globalization.

The Minor in Anthropology requires that students complete two "Introductory and Methods" courses (18 units) and four "Anthropological Perspectives" courses (36 units). In addition, 79-104 Global Histories is required (9 units), but it may be taken at any time during the student's coursework. Including this course, the Minor in Anthropology totals 63 units.

The minor in Anthropology involves a minimum of 54 units of History Department course work (not including 79-104 Global Histories), as described below.

Curriculum (63 units)

I. Required General Education Course (9 units)

This requirement need not be satisfied before beginning any minor in the History Department.

79-104	Global Histories	9
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II. Introductory and Methods Courses (18 units)

Students must complete 18 units (typically 2 courses) for the Introductory and Methods Courses, selecting from the list below.

79-201	Introduction to Anthropology	9
79-297	Dilemmas and Controversies in Anthropology	9
79-380	Ethnographic Methods	9

III. Anthropological Perspectives _ (36 units)

Students must complete 36 units (typically 4 courses) for Anthropological Perspectives Courses, selecting from the list below.

79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-221	Development and Democracy in Latin America	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-224	Mayan America	9
79-235	Caribbean Cultures	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-275	Introduction to Global Studies	9
79-276	Beyond the Border	6
79-278	Rights to Representation: Indigenous People and their Media	9
79-295	Race Relations in the Atlantic World	9
79-296	Perspectives on Social Protest	9
79-299	Trafficking Persons: Children in a Global Context	9
79-312	International Human Rights Institutions in Theory and Practice	6
79-314	The Politics and Culture of Memory	9
79-315	Hawai'i: America's Pacific Island State	9
79-317	Art, Anthropology, and Empire	9
79-332	Medical Anthropology	9
79-342	Introduction to Science and Technology Studies	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9

Senior Honors Thesis: Dietrich College

The Dietrich College Honors Program may be undertaken by students completing the major in Social & Political History, the major in Global Studies, or the interdepartmental major in Ethics, History, and Public Policy. An Honors Thesis requires two semesters of work. Eligibility requirements are set by the College; contact the Associate Dean of Dietrich College for details.

Senior Thesis: History Department

Seniors may write a one- or two-semester Senior Thesis in History (which differs from the "Honors Thesis" option, described above) with permission of the Director of Undergraduate Studies and a designated History faculty member who will supervise its completion.

Study Abroad

Study abroad is especially encouraged for all students in the History Department; this experience can help students better understand the relationship between cultural heritage and modern political processes in a host country. To make study abroad successful and to find how study abroad fits into requirements, History majors should prepare study abroad proposals in consultation with a relevant faculty member.

Faculty

CAROLINE JEAN ACKER, Associate Professor of History – Ph.D., University of California, San Francisco; Carnegie Mellon, 1993–.

JAY D. ARONSON, Associate Professor of History; Director of Ethics, History, and Public Policy – Ph.D., University of Minnesota; Carnegie Mellon, 2004–.

ALLYSON F. CREASMAN, Associate Professor of History – Ph.D., University of Virginia; Carnegie Mellon, 2005–.

LAURIE Z. EISENBERG, Teaching Professor of History – Ph.D., University of Michigan; Carnegie Mellon, 1992–.

PAUL EISS, Associate Professor of Anthropology and History – Ph.D., University of Michigan; Carnegie Mellon, 2000–.

EDDA FIELDS-BLACK, Associate Professor of History – Ph.D., University of Pennsylvania; Carnegie Mellon, 2001–.

WENDY Z. GOLDMAN, Professor of History – Ph.D., University of Pennsylvania; Carnegie Mellon, 1988–.

EMANUELA GRAMA, Assistant Professor of Anthropology and History – Ph.D., University of Michigan; Carnegie Mellon, 2013–.

DONNA HARSCH, Professor of History; Department Head – Ph.D., Yale University; Carnegie Mellon, 1990–.

RICKY W. LAW, Assistant Professor of History – Ph.D., University of North Carolina; Carnegie Mellon, 2013–.

KATHERINE A. LYNCH, Professor of History; Director of Graduate Studies – Ph.D., Harvard University; Carnegie Mellon, 1980–.

CHRISTOPHER J. PHILLIPS, Assistant Professor of History – Ph.D., Harvard University; Carnegie Mellon, 2014–.

BENJAMIN REILLY, Associate Teaching Professor of History, Carnegie Mellon-Qatar – Ph.D., University of Pittsburgh; Carnegie Mellon, 2004–.

SCOTT A. SANDAGE, Associate Professor of History – Ph.D., Rutgers University; Carnegie Mellon, 1995–.

JUDITH SCHACHTER, Professor of Anthropology and History – Ph.D., University of Minnesota; Carnegie Mellon, 1984–.

STEVEN SCHLOSSMAN, Professor of History; Director of Undergraduate Studies – Ph.D., Columbia University; Carnegie Mellon, 1988–.

NICO SLATE, Associate Professor of History – Ph.D., Harvard University; Carnegie Mellon, 2009–.

JOHN SOLURI, Associate Professor of History; Director of Global Studies – Ph.D., University of Michigan; Carnegie Mellon, 1999–.

JOEL A. TARR, Richard S. Caliguiri University Professor of History and Policy – Ph.D., Northwestern University; Carnegie Mellon, 1967–.

LISA M. TETRAULT, Associate Professor of History – Ph.D., University of Wisconsin; Carnegie Mellon, 2005–.

JOE WILLIAM TROTTER, Giant Eagle Professor of History and Social Justice – Ph.D., University of Minnesota; Carnegie Mellon, 1985–.

BENNO R. WEINER, Assistant Professor of History – Ph.D., Columbia University; Carnegie Mellon, 2015–.

Special Faculty

JOSEPH E. DEVINE, Associate Dean for Undergraduate Studies, Dietrich College of Humanities and Social Sciences – D.A., Carnegie Mellon University; Carnegie Mellon, 1979–.

KAREN FAULK, Visiting Assistant Professor of Anthropology and History – Ph.D., University of Michigan; Carnegie Mellon, 2009–.

MICHAL R. FRIEDMAN, Visiting Assistant Professor of History – Ph.D., Columbia University; Carnegie Mellon, 2010–.

TIMOTHY HAGGERTY, Director of the Humanities Scholars Program – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2000–.

LANSINE KABA, Distinguished Visiting Professor of History, Carnegie Mellon-Qatar – Ph.D., Northwestern University; Carnegie Mellon, 2009–.

NAUM KATS, Undergraduate Advisor, Department of History – Ph.D., University of Saint Petersburg, Russia; Carnegie Mellon, 1990–.

Emeriti

EDWIN FENTON, Professor Emeritus of History - Ph.D., Harvard University; Carnegie Mellon, 1954-.

DAVID H. FOWLER, Professor Emeritus of History - Ph.D., Yale University; Carnegie Mellon, 1959-.

RICHARD MADDOX, Professor Emeritus of Anthropology and History - Ph.D., Stanford University; Carnegie Mellon, 1993-.

DAVID W. MILLER, Professor Emeritus of History - Ph.D., University of Chicago; Carnegie Mellon, 1967-.

JOHN MODELL, Professor Emeritus of History - Ph.D., Columbia University; Carnegie Mellon, 1982-.

DANIEL P. RESNICK, Professor Emeritus of History - Ph.D., Harvard University; Carnegie Mellon, 1966-.

DONALD S. SUTTON, Professor of History and Anthropology - Ph.D., Cambridge University, England; Carnegie Mellon, 1969-.

The Major in Information Systems

Faculty Program Director: Randy S. Weinberg

Office: Porter Hall 222

<http://www.cmu.edu/information-systems/>

Information Systems (IS), found within the Dietrich College of Humanities and Social Sciences, is an internationally recognized undergraduate major for students who want to design and implement effective solutions to meet organizational, societal and management needs for information and decision support.

In today's complex, interconnected world, the effective creation, distribution, and use of information via technology is central to daily life. Computer based information systems facilitate, enable and often define the relationships between corporations and consumers, buyers and suppliers, businesses of all sizes, social networks, and citizens and their governments. Understanding these relationships and effectively addressing the collection, flow, and distribution of information is vital to running a modern organization, enterprise or government agency.

Information Systems involves the effective design, delivery, use and impact of information and communications technologies in organizations and society. The importance of information technology and information systems to organizations and the need for well-educated professionals in the field is the basis for the Information Systems curriculum at Carnegie Mellon. Whether implementing applications, providing management or decision support, managing complex systems projects, or helping organizations design business processes or cope with rapid change, IS professionals fill an essential need across all sectors of society.

Information systems students at Carnegie Mellon learn to use, manage and deploy information technologies to address real problems or opportunities. They develop a solid foundation in computing, communications, as well as software development principles, languages, and methods. Since Information Systems generally operate within organizations, IS students study social sciences and organizational theory. IS students learn how to right-size information technology solutions to meet real-world economic and organizational constraints. Information Systems students also learn, through hands-on experience, the critical importance of professional communications, problem analysis, critical thinking and teamwork. Building on the multi-disciplinary strengths of the university and the Dietrich College of Humanities and Social Sciences, graduates in Information Systems are ideally suited to take a leading role in shaping our information-based future.

The flexible nature of the program encourages students to explore their own interests through program electives, study in a contemporary content area or through optional second majors and minors.

IS students are well prepared to pursue graduate work in a wide range of fields. For students interested in master's degree-level graduate work at Carnegie Mellon, there are many possibilities, including accelerated Masters degree programs in Information Systems Management, Human Computer Interaction, Information Security Policy and Management, Engineering Technology and Innovation Management, and Business Administration.

IS graduates continue to be in high demand in the information-age workplace. There has been a strong job market for IS students in recent years, and national trends indicate that this is likely to continue. IS majors often take jobs in consulting companies, major software firms, large corporations, and start-up companies. Internship opportunities closely parallel the job market.

In addition to the Dietrich College General Education Requirements and basic prerequisites in Mathematics, Statistics and Computer Science, IS students must complete the Professional Core, the Disciplinary Core and a focused Content Area. In the Professional Core (consisting of six courses), students learn the basic skills necessary to analyze, design, implement and test high-quality, cost effective information systems. Two of the Professional Core courses are project-based experiences in which small teams of students develop and deliver solutions to real information problems.

In the Disciplinary Core (consisting of three courses), students study key areas fundamental to understanding and solving problems in information systems: professional communications; quantitative analysis and research methods; and organizations, policy, and social science.

IS students also complete three courses within one Content Area. The content areas are designed to provide students an opportunity to gain additional depth in a focused area. Currently, twelve content areas are available: (1) Business / Enterprise Systems, (2) Computing and Information Systems & Technology, (3) Social and Global Systems, (4) Quantitative Analysis, (5) Game Design, (6) Animation and Special Effects, (7) Media

Design, (8) Learning Media, (9) Sound Design, (10) Entrepreneurship for Creative Industries, (11) Intelligent Environments, (12) Physical Computing. Content areas (5) through (12) are offered through CMU's Integrative Design, Arts, and Technology (IDeATe) (<http://www.cmu.edu/ideate>) initiative combining arts and technology.

Study Abroad Options in Information Systems

Given the rise of globalization and its effect on information systems development, we encourage students to consider expanding their international experience by spending a semester studying abroad. The IS program is very flexible in allowing students to pursue these opportunities. With careful planning, study abroad is possible during most semesters. Students interested in study abroad should talk with the IS Academic Advisor to help plan an appropriate course of study. With prior approval, study abroad courses may be applied to major requirements.

Information Systems as Additional Major or Minor

Information Systems is not available as either an additional major or minor.

Transfer into Information Systems

Most IS students are admitted directly into Information Systems as incoming freshmen. Only Information Systems major students are permitted to enroll in the Professional Core courses (67-250 and above), and IS students have enrollment priority in IS electives.

Students in high academic standing may apply to be admitted to the Information Systems major as transfer students. Transfers into Information Systems will always be subject to availability of space in the major. Applications will be considered based on the following criteria:

- Strong record of academic performance at Carnegie Mellon (minimum QPA of 3.4)
- Relevance and clarity of personal statement
- Interviews with IS Academic Advisor and Dietrich College Academic Advisory Center (AAC) Advisors or Assistant Dean (AAC)
- Relevance of courses completed to date
- Completion of 15-112 Fundamentals of Programming and Computer Science with final grade of 'A' or 'B'

Applications for admission to the major are considered at the end of each Fall and Spring semester. Application materials must be submitted to the Academic Advising Center no later than the last day of classes of the fall or spring semester.

Students accepted as transfers to the IS program would normally be expected to complete the usual prerequisites and begin the Professional Core courses during the next available semester.

Dietrich College undergraduate students who want to transfer to IS must apply through the Dietrich College Academic Advisory Center, Baker Hall A56. Undergraduate students in other Carnegie Mellon colleges who wish to transfer to the Dietrich College and then into Information Systems should also apply through the Dietrich College Academic Advisory Center (<http://www.cmu.edu/hss/advisory-center/transferring/transfer-in.html>), Baker Hall A57. Students from other Carnegie Mellon colleges must be approved for admission to both the Dietrich College and Information Systems.

Students interested in applying for transfer to the Information Systems major should contact the IS Academic Advisor for information regarding availability, application procedures and deadlines. Potential applicants to the IS major should be working toward a sensible alternative major, so that their success at Carnegie Mellon is not predicated on admission to the IS program.

Curriculum

The Information Systems major is offered only as a Bachelor of Science (B.S.) degree. In addition to major requirements outlined below, all Information Systems students must fulfill the General Education

requirements for the Dietrich College of Humanities and Social Sciences. A total of 360 units is required for the degree.

Requirements are subject to revision. Advisor approval is required for each student's major curriculum plan. Any proposed course substitutions to courses required for the IS major must be approved in advance by the IS Academic Advisor.

Prerequisites

Information Systems requires completion of prerequisite courses in Mathematics, Statistics and Computer Science. All prerequisites must be successfully completed prior to the start of Fall semester, junior year.

Mathematics and Statistics

Complete one of the following calculus sequences:

		Units
21-111	Calculus I	10
21-112	Calculus II	10

OR

		Units
21-120	Differential and Integral Calculus	10
21-256	Multivariate Analysis (Required for advanced business courses)	9

OR

		Units
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation (Required for advanced computer science courses)	10

AND also complete:

		Units
36-201	Statistical Reasoning and Practice	9

Computer Science

Three Computer Science courses are required. To maintain normal progress toward the Information Systems degree, students must complete 15-121 Introduction to Data Structures prior to the start of Spring Semester, sophomore year.

Students entering the program as freshmen will complete a Computer Science Placement Test. Depending on appropriate Advanced Placement credit and results of the Computer Science Placement Test, entering students may place directly into 15-112 or 15-121. 15-110 is taken as the first Computer Science prerequisite unless a student places directly into 15-112 or 15-121. Most students entering the program will begin the sequence with 15-110.

		Units
15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
15-121	Introduction to Data Structures	10

Note: Students cannot receive credit for both 15-104 Introduction to Computing for Creative Practice and 15-110 Principles of Computing.

Professional Core

The Professional Core consists of six courses (five core courses and one core elective).

Complete all five of these courses:

		Units
67-250	The Information Systems Milieux (Spring Semester Only)	9
67-262	Database Design and Development (Fall Semester Only)	9
67-272	Application Design and Development (Spring Semester Only)	9
67-373	Software Development Project (Spring Semester Only)	12
67-475	Innovation in Information Systems (Fall Semester Only)	12

Core courses are only offered once per academic year.

Note: Students transferring into Information Systems may substitute 67-344 Organizational Intelligence in the Information Age for 67-250 The Information Systems Milieux.

Professional Core Elective

Plus, complete 6 to 12 units chosen from the following options:

		Units
19-402	Telecommunications Technology, Policy & Management	12
67-306	Special Topics: Management of Computer and Information Systems	6
67-308	Innovation Studio: Health Care Information Systems	9
67-309	Special Topics	6
67-311	Database Design and Implementation	9
67-319-67-331	Global Technology Consulting Groundwork - Technology Consulting in the Global Community (these two courses are taken sequentially)	6
67-327	Web Application Security	6
67-328	Mobile to Cloud: Building Distributed Applications	9
67-329	Contemporary Themes in Global Systems	9
67-330	Technology Consulting in the Community	9
67-344	Organizational Intelligence in the Information Age	9
67-353	IT & Environmental Sustainability	6
67-362	Big Data and Analytics	9
67-370	Intelligent Decision Support Systems	9
67-442	Mobile Application Development in iOS	9
88-223	Decision Analysis and Decision Support Systems	9

OR Any Computer Science course above 15-121 with prerequisite of 15-112 or higher.

OR Any Human-Computer Interaction course (05-xxx).

OR other *pre-approved* 67-3xx or 67-4xx which may be offered from time to time. Students wishing to apply such courses to their Professional Core requirement must complete a course substitution application through the IS Academic Advisor.

OR other *pre-approved* courses offered by the Engineering & Public Policy Department (19-xxx).

NOTE: 67-1xx and 67-2xx courses may not be applied to this requirement.

Disciplinary Core

Complete one course (9 units) from each of the three Disciplinary Core categories.

Professional Communications

Information systems professionals communicate with a wide range of people in most organizations and often facilitate communications between diverse groups of stakeholders. Consequently, the most successful professionals typically are those with strong communication skills. These courses help students see that the structure and presentation of information affects how well (and how easily) it can be understood and used.

Complete one course (9 units). It is recommended that this requirement be completed by the end of junior year:

		Units
15-221	Technical Communication for Computer Scientists	9
36-315	Statistical Graphics and Visualization	9
51-261	Communication Design Fundamentals: Design for Interactions for Communications	9
or 51-262	Communication Design Fundamentals: Design for Interactions for Communications	
70-321	Negotiation and Conflict Resolution	9
70-340	Business Communications	9
70-341	Organizational Communication	9
70-342	Managing Across Cultures	9
76-270	Writing for the Professions	9
76-272	Language in Design	9
88/70/85-341	Organizational Communication	9

Quantitative Analysis and Research Methods

This area focuses on decision making and data analysis — essential to development of useful information systems. This area exposes students to analytic methods in the social sciences and quantitative methods for approaching complex methods.

Complete one course (9 units). It is recommended that this requirement be completed in the sophomore year:

	Units
21-257	9
21-325	9
36-202	9
36/70-208	9
36-217	9
36-225	9
36-303	9
36-309	9
67-360	9
67-362	9
67-370	9
80-305	9
80-405	9
88-223	9
88-251	9

Organizations, Policy, and Social Science

The focus of this area is on how organizations function in modern social and economic environments. Students will develop a greater understanding of how social policy and technology influence organizations and how they operate.

Complete one course (9 units):

	Units
08-200/19-211	9
15-390/70-421	9
19-402	12
19-403	12
19-411	9
67-308	9
67-344	9
67-353	6
70-311	9
70-332	9
70/85/88-341	9
70-342	9
70-414	9
70-415	9
70-416	9
70-420	9
70-437	9
80-341	9
88-220	9
88-223	9
88-260	9

Content Area

Complete a minimum of 27 units from one of the Content Areas below. No Content Area course may also be used to fulfill a Disciplinary Core or Professional Core requirement.

Business/Enterprise Systems

This content area broadens a student's knowledge in the business, economics and policy aspects of large scale information systems.

	Units
19-402	12

19-411	Global Competitiveness: Firms, Nations and Technological Change	9
67-301	Networks and Telecommunications	9
67-306	Special Topics: Management of Computer and Information Systems	6
67-308	Innovation Studio: Health Care Information Systems	9
67-309	Special Topics	6
67-311	Database Design and Implementation	9
67-319-67-331	Global Technology Consulting Groundwork - Technology Consulting in the Global Community (these two courses are taken sequentially)	6
67-328	Mobile to Cloud: Building Distributed Applications	9
67-330	Technology Consulting in the Community	9
67-344	Organizational Intelligence in the Information Age	9
67-353	IT & Environmental Sustainability	6
67-370	Intelligent Decision Support Systems	9
67-442	Mobile Application Development in iOS	9
70-332	Business, Society and Ethics	9
70-366	Intellectual Property and E-Commerce	6
70-371	Operations Management	9
70-414	Entrepreneurship for Engineers	9
or 70-415	Introduction to Entrepreneurship	
or 70-420	Entrepreneurship for Scientists	
or 70-421	Entrepreneurship for Computer Scientists	
70-437	Organizational Learning and Strategic Management	9
70-438	Commercialization and Innovation	9
70-443	Digital Marketing and Social Media Strategy	9
70-449	Social, Economic and Information Networks	9
70-455	Modern Data Management	9
70-460	Mathematical Models for Consulting	9
70/73-465	Technology Strategy	9
70-471	Supply Chain Management	9
70-476	Service Operations Management	9
73-359	Benefit-Cost Analysis	9
73-469	Global Electronic Markets: Economics and the Internet	9
76-391	Document & Information Design	12
76-487	Web Design	12

Computing and Information Systems & Technology

This content area allows students to focus on current and emerging technologies.

		Units
05-391	Designing Human Centered Software	12
05-410	User-Centered Research and Evaluation	12
05-430	Programming Usable Interfaces	15
05-431	Software Structures for User Interfaces	15
05-432	Personalized Online Learning	12
05-433	Programming Usable Interfaces OR Software Structures for Usable Interfaces	6
05-499	Special Topics in HCI	Var.
16-311	Introduction to Robotics	12
16-362	Mobile Robot Programming Laboratory	12
19-403	Policies of Wireless Systems and the Internet	12
19-411	Global Competitiveness: Firms, Nations and Technological Change	9
60-415	Advanced ETB: Animation	10
67-311	Database Design and Implementation	9
67-327	Web Application Security	6
67-328	Mobile to Cloud: Building Distributed Applications	9
67-362	Big Data and Analytics	9
67-442	Mobile Application Development in iOS	9
Any 15-xxx course above 15-121 with prerequisite of 15-112 or higher		

Social and Global Systems

This content area exposes students to key themes in globalization and global systems . management, policy, international business, and technology.

	Units
19-402 Telecommunications Technology, Policy & Management	12
19-403 Policies of Wireless Systems and the Internet	12
19-411 Global Competitiveness: Firms, Nations and Technological Change	9
67-319-67-331 Global Technology Consulting Groundwork - Technology Consulting in the Global Community (these two courses are taken sequentially)	6
67-329 Contemporary Themes in Global Systems	9
67-330 Technology Consulting in the Community	9
67-353 IT & Environmental Sustainability	6
70-342 Managing Across Cultures	9
70-365 International Trade and International Law	9
70-430 International Management	9
70-480 International Marketing	9
73-372 International Money and Finance	9
76-318 Communicating in the Global Marketplace	9
76-386 Language & Culture	9
79-318 Sustainable Social Change: History and Practice	6
79-381 Energy and Empire: How Fossil Fuels Changed the World	9
88-371 Entrepreneurship, Regulation and Technological Change	9
88-378 International Economics	9
88-384 Conflict and Conflict Resolution in International Relations	9
88-391 Technology and Economic Growth	9
88-410 The Global Economy: A User's Guide	9
88-411 Rise of the Asian Economies	9

Additionally, other *pre-approved* courses offered by the Engineering & Public Policy Department (19-xxx) may be used to fulfill the Social and Global Systems Content Area.

Quantitative Analysis

Students will learn to apply analytic and quantitative methods for approaching complex, ambiguous problems.

	Units
21-257 Models and Methods for Optimization	9
21-292 Operations Research I	9
36/70-208 Regression Analysis	9
36-217 Probability Theory and Random Processes or 36-225 Introduction to Probability Theory	9
36-303 Sampling, Survey and Society	9
36-309 Experimental Design for Behavioral and Social Sciences	9
36-350 Statistical Computing	9
36-401 Modern Regression	9
36-410 Introduction to Probability Modeling or 36-46x Topics in Statistics	9
67-360 Applied Analytics	9
67-362 Big Data and Analytics	9
67-370 Intelligent Decision Support Systems	9
70-460 Mathematical Models for Consulting	9
70-462 Stochastic Modeling and Simulations	9
73-363 Econometrics	9
88-223 Decision Analysis and Decision Support Systems	9
88-251 Empirical Research Methods	9

Integrative Design, Arts, and Technology (IDeATe) Content Areas:

An IDeATe content area consists of a minimum of 27 units which may include one Portal Course (other than 15-104 Introduction to Computing for Creative Practice) plus 2 courses from one of the areas below.

Game Design (IDeATe)

In this content area, students will learn both theory and skill in the key areas of games: dramatic narrative and character development, visual and sound synthesis, special effects and performance capture, programming and engine development, interface and interaction architecture development, game assessment and redesign. Please visit the Game Design website (<http://www.cmu.edu/ideate/concentrations-and-minors/game-design.html>) for information about available courses.

Animation and Special Effects (IDeATe)

The interconnected components of performance capture, rendering, 3D and 2D animation, and special effects will be covered in this content area. Course information can be found at the Animation and Special Effects website (<http://www.cmu.edu/ideate/concentrations-and-minors/animation-and-special-effects.html>).

Media Design (IDeATe)

The digital mediation of experiences content area explores the interconnected development of technology and content in new media systems and the meaning that arises from the resulting forms. Students learn to design mediated experiences across different platforms, from mobile to large-scale installations. Course information can be found on the Media Design website (<http://www.cmu.edu/ideate/concentrations-and-minors/media-design.html>).

Learning Media (IDeATe)

Students in this content area will combine their diverse skills for the design of effective new media systems for learning; from games for learning to tangible learning tool kits and remote learning systems. They will leverage new technologies, media arts knowledge, and learning science principles to create engaging experiences with measurable real world impact. For course information, please visit the Learning Media website (<http://www.cmu.edu/ideate/concentrations-and-minors/learning-media.html>).

Sound Design (IDeATe)

This content area will explore the processes and products of digital sound and music. Students will receive basic training in key areas: principles of computer music, hybrid instrument building, concepts in sound design. 62-150 Intro to Signal Processing for Creative Practice (10 units) is the required portal course for this content area and will serve as one of the courses for this content area. Course information can be found at the Sound Design website. (<http://www.cmu.edu/ideate/concentrations-and-minors/sound-design.html>)

Entrepreneurship for Creative Industries (IDeATe)

Students in this content area will develop the knowledge and skills to lead and innovate in creative industries. Their interdisciplinary, hands-on coursework will emphasize the conceptualization of innovative products and the structuring of innovation processes. Courses and additional information can be found at the Entrepreneurship for Creative Industries website (<http://www.cmu.edu/ideate/concentrations-and-minors/entrepreneurship-for-creative-industries.html>).

Intelligent Environments (IDeATe)

The focus of this content area is on spaces that support efficiency and high quality of experience, addressing both the integrated development of such environments and the resulting experience. The required portal course for this content area is 62-150 Intro to Signal Processing for Creative Practice (10 units) or 16-223/60-223 Introduction to Physical Computing (10 units) and will serve as one of the courses for this content area. Course information can be found at the Intelligent Environments website (<http://www.cmu.edu/ideate/concentrations-and-minors/intelligent-environments.html>).

Physical Computing (IDeATe)

The barriers between computing devices and their users have slowly dissolved. The physical world is becoming a key interface for computing and the internet of things is becoming the next generation of connectivity. Students in this content area will explore the technical, experiential, and semantic issues of this evolution. Course information can be found on the Physical Computing website (<http://www.cmu.edu/ideate/concentrations-and-minors/physical-computing.html>).

Double Counting of Courses

"Double Counting" refers to instances when a course taken to fulfill one requirement counts simultaneously toward a requirement in another major or minor program. Double Counting is permitted in the Dietrich College on a very limited basis. Information Systems students may double count

no more than two courses used to fulfill any Information Systems major requirement (beyond the Dietrich College General Education requirements and Prerequisite courses) with any combination of dual degrees, additional majors, minors or graduate degree programs. Only one course may double count with any minor. No course can count for more than one requirement within the major. Students must also adhere to any policy restrictions on double counting enforced by the academic department of the student's additional major or minor.

Course Repeats

Per university policy, when a course is repeated, all grades will be recorded on the official academic transcript and will be calculated in the student's QPA. This is the case regardless if the first grade for the course is a passing or failing grade.

Undergraduate students who wish to repeat a course already passed must obtain approval from the student's Dean or Department Head. When a student takes a course s/he has already passed, only one set of units will count towards graduation requirements.

Information Systems Sample Curriculum

Freshman		Sophomore	
Fall	Spring	Fall	Spring
67-100 Information Systems Freshman Workshop	67-250 The Information Systems Milieux	67-262 Database Design and Development	67-272 Application Design and Development
15-110 Principles of Computing	15-112 Fundamentals of Programming and Computer Science	15-121 Introduction to Data Structures	Disciplinary Core Course
21-111 Calculus I	21-112 Calculus II	Disciplinary Core Course	Elective Course
36-201 Statistical Reasoning and Practice	76-101 Interpretation and Argument	Elective Course	Elective Course
Freshman Seminar	79-104 Global Histories	Elective Course	Elective Course
99-101 Computing @ Carnegie Mellon Elective Course			

Junior		Senior	
Fall	Spring	Fall	Spring
Professional Core Elective Course	67-373 Software Development Project	67-475 Innovation in Information Systems	Content Area Course
Disciplinary Core Course	Content Area Course	Content Area Course	Elective Course
Elective Course	Elective Course	Elective Course	Elective Course
Elective Course	Elective Course	Elective Course	Elective Course
Elective Course	Elective Course	Elective Course	Elective Course

Faculty

C.F. LARRY HEIMANN, Teaching Professor - Ph.D., Washington University (St. Louis); Carnegie Mellon, 1998-.

JOSEPH S. MERTZ, Teaching Professor (joint Appointment with Heinz College) - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1997-.

JERIA QUESENBERRY, Associate Teaching Professor - Ph.D., Pennsylvania State University; Carnegie Mellon, 2007-.

RAJA SOORIAMURTHI, Teaching Professor - Ph.D., Indiana University; Carnegie Mellon, 2007-.

RANDY S. WEINBERG, Teaching Professor; Program Director, Information Systems - Ph.D., University of Minnesota; Carnegie Mellon, 1998-.

CHADI AOUN, Associate Teaching Professor - Carnegie Mellon - Qatar - Ph.D., University of New South Wales; Carnegie Mellon, 2015--.

ANIS CHARFI, Associate Teaching Professor - Carnegie Mellon - Qatar - Dr. Ing., Technische Universität Darmstadt; Carnegie Mellon, 2015-.

ALEX CHEEK, Assistant Teaching Professor - Carnegie Mellon - Qatar - M.Des., Carnegie Mellon University; Carnegie Mellon, 2014-.

DIVAKARAN LIGINLAL, Teaching Professor - Carnegie Mellon - Qatar - Ph.D., University of Arizona - Tucson; Carnegie Mellon, 2009-.

SELMA LIMAM MANSAR, Teaching Professor - Carnegie Mellon - Qatar - Ph.D., National Polytechnic Institute of Grenoble; Carnegie Mellon, 2007-.

DANIEL PHELPS, Associate Teaching Professor - Carnegie Mellon - Qatar - Ph.D., Florida State University; Carnegie Mellon, 2007-.

RAY TSAI, Professor of Practice - Carnegie Mellon - Qatar - Ph.D., University of North Texas; Carnegie Mellon, 2011-.

Department of Modern Languages

Susan G. Polansky, Department Head
Bonnie L. Youngs, Director of Undergraduate Studies
Department Office: Baker Hall 160
<http://www.cmu.edu/dietrich/modlang/>

Studying foreign languages and their cultures is desirable and essential for understanding our complex global world. It is crucial to educate global citizens who will be sensitive to other cultures and capable of communicating in other languages. Proficiency in a foreign language by itself, or combined with other professional training, may lead to a variety of rewarding careers. Moreover, the personal experience of mastering another language is enriching and gratifying.

The Majors in Chinese Studies, French & Francophone Studies, German Studies, Hispanic Studies, Japanese Studies, and Russian Studies

These majors are designed to lead to acquisition of communicative language proficiency and substantive knowledge of other cultures.

Drawing on the unique interdisciplinary climate of the Carnegie Mellon campus, the undergraduate majors in Modern Languages encourage the acquisition of multiple skills by students with varied backgrounds, talents, and interests. An important resource in support of these goals is the Modern Language Resource Center (MLRC), a state-of-the-art facility that provides students with access to authentic foreign language materials such as original television broadcasts, interactive video projects, Technology Enhanced Language Learning (TELL) courses, international audio and video resources, and computerized assessment tools.

Students majoring in a modern language are also encouraged to enroll, preferably during their junior year, in a study-abroad program or to spend a summer abroad at a language institute or in an internship. Semester or year-long programs are available in places such as China, France, Germany, Japan, Africa, Russia, Spain, and Latin America. The Department also sponsors summer courses in China, Germany, and Spain. Foreign film series, informal conversation tables, native-speaker conversation partners, speaking and writing assistants, and Student Advisory Committee cultural events are some of the activities organized by the Department of Modern Languages to increase students' ability in languages and knowledge of cultures.

The major in Modern Languages is designed to permit students to acquire communicative language proficiency in their language of specialization. Courses in culture and civilization offer students a solid introduction to the main currents in national literatures as well as artistic and social movements. These courses integrate study of cultures with skill development in reading, writing, and aural/oral communication. In addition, the student who majors in Modern Languages will develop a perspective on the learning and use of second languages, from both a social and cognitive point of view, within contemporary American society and in an increasingly global community. Working closely with their advisor, language majors are guided to develop personal interests by taking courses in other disciplines such as fine arts, history, psychology, philosophy, and other humanities and social sciences, which often include readings, discussions, and papers in the foreign language. The rich technological environment of the campus strongly enhances all fields of language study.

Second language proficiency is an asset which provides students with practical as well as theoretical bases for a variety of paths after graduation. Students of Modern Languages have taken paths to a wide variety of careers in government, entrepreneurship and business, law, technology and engineering firms, media, public health, health policy, and health professions, non-profit organizations, entertainment and creative arts, and education. They are also prepared to pursue graduate studies in second language-related fields (e.g. linguistics, second language acquisition, literary and cultural studies).

Curriculum

Six specializations are available in the Department of Modern Languages: Chinese Studies, French and Francophone Studies, German Studies, Hispanic Studies, Japanese Studies, and Russian Studies.

Language-specific faculty advisors for these majors are:

Chinese Studies- Dr. Elisabeth Kaske, Associate Professor of Chinese Studies and Dr. Yueming Yu, Teaching Professor of Chinese Studies
French & Francophone Studies-Dr. Bonnie Youngs, Teaching Professor of French & Francophone Studies
German Studies-Dr. Stephen Brockmann, Professor of German
Hispanic Studies-Dr. Therese Tardio, Associate Teaching Professor of Hispanic Studies
Japanese Studies-Dr. Yasufumi Iwasaki, Associate Teaching Professor of Japanese and Dr. Keiko Koda, Professor of Japanese and Second Language Acquisition
Russian Studies-Dr. Charlene Castellano, Teaching Professor of Russian

The Major in Chinese Studies96-99 units

Faculty Advisors

Dr. Elisabeth Kaske, Associate Professor of Chinese Studies (ekaske@andrew.cmu.edu) Dr. Yueming Yu, Teaching Professor of Chinese Studies (yyu@andrew.cmu.edu)

Prerequisites

Intermediate-level proficiency in the Chinese language. This is equivalent to the completion of three courses (two at the 100-level and one at the 200-level), or placement or exemption based on Advanced Placement, International Baccalaureate or CMU internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all majors. (Study abroad advisor - Dr. Yueming Yu, yyu@andrew.cmu.edu)

Students with native or near-native proficiency in listening and speaking of the language prior to entering CMU should consult with the major advisor for a different curriculum that may accelerate their completion of the requirement.

Students may double count a maximum of one course taken for the Chinese Studies major that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in Chinese Studies39-42 units*

Complete all four courses

		Units
82-232	Intermediate Chinese II (may be substituted by 82-235 Intermediate Chinese for Heritage Students)	12
82-331	Advanced Chinese I	9
82-332	Advanced Chinese II	9
82-333	Introduction to Chinese Language and Culture **	Var.

*Students who place out of 82-232/82-235 must take a minimum of 9 additional units chosen from List A Electives.

**Students must take this course for 12 units to fulfill the requirement. Students who take this course for 9 units prior to declaring their major must register for 3 units of independent study later in their studies.

2. Core Courses in Modern Languages12 units

Complete one 9 unit course* plus the Senior Seminar (3 units) in the spring of the senior year.

		Units
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
82-580	Senior Seminar in Modern Languages	3

* In consultation with the major advisor, students may substitute a Modern Languages course elective with one related to language analysis, language learning, or acquisition of language and culture from the listings in Chinese Studies or from another department. Examples: 80-180 Nature of Language, 85-421 Language and Thought.

3. Core Courses in History & Society 9 units

Complete one course after consultation with the major advisor and the designated History or Modern Languages professor.

	Units
79-261 Chinese Culture and Society	9
79-262 Modern China	9
79-309 20th Century China Through Film	9
82-230 Topics in Cultural Comparison	9
82-234 Topics in Chinese History	9
82-237 Topics in Traditional China	9
82-238 Topics in Chinese Culture	9

4. Chinese Studies and Interdisciplinary Electives 36 units

Complete two courses (18 units) from List A and two courses (18 units) from List B, or two courses (18 units) from List A, one (9 units) from List B, and one (9 units) from List C.

List A. Core Chinese Studies Electives 18 units

	Units
82-432 Popular Culture in China	9
82-433 Topics in Contemporary Culture of China *	9
82-434 Studies in Chinese Traditions *	9
82-436 Introduction to Classical Chinese	9
82-439 Modern China Through Literature *	9
82-440 Studies in Chinese Literature & Culture *	9
82-531/532 Special Topics in Chinese Studies *	Var.

*Students may repeat these courses with new topics.

List B: Chinese Studies Electives (minimum) 9 units

	Units
82-334 Structure of Chinese	9
82-335 Readings in Chinese	9
82-337 Mandarin Chinese for Oral Communication I	9
82-338 Mandarin Chinese for Oral Communication II	9
82-339 Business Language & Culture in China I	9
82-340 Business Language & Culture in China II	9
82-432 Popular Culture in China	9
82-439 Modern China Through Literature	9
82-440 Studies in Chinese Literature & Culture	9
82-432 Popular Culture in China	9
82-433 Topics in Contemporary Culture of China *	9
82-434 Studies in Chinese Traditions *	9
82-436 Introduction to Classical Chinese	9
82-439 Modern China Through Literature *	Var.
82-440 Studies in Chinese Literature & Culture *	9
82-436 Introduction to Classical Chinese	9
82-505 Undergraduate Internship	Var.
82-531/532 Special Topics in Chinese Studies *	Var.

* Students may repeat these courses with new topics.

List C. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their major advisor for the most up to date interdisciplinary electives appropriate for the Chinese Studies curriculum. Courses may be suggested to the major advisor for approval as a substitute. Note that not all courses are offered each semester.

	Units
Architecture	
48-351 Human Factors in Architecture	9
48-551 Ethics and Decision Making in Architecture	9
Art	
60-373 Aesthetics from a Global Viewpoint	9
60-399 Art History/Theory Independent Study	9
Business	
	Units

70-342	Managing Across Cultures	9
70-365	International Trade and International Law	9
70-430	International Management	9

	Units	
English		
76-318	Communicating in the Global Marketplace	9
76-339	Topics in Film Studies	9
76-386	Language & Culture	9
76-387	Narrative & Argument	9

	Units	
History		
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-309	20th Century China Through Film	9

	Units	
Modern Languages		
82-230	Topics in Cultural Comparison	9
82-234	Topics in Chinese History	9
82-237	Topics in Traditional China	9
82-238	Topics in Chinese Culture	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9

	Units	
Philosophy		
80-180	Nature of Language	9
80-280	Linguistic Analysis	9
80-276	Philosophy of Religion	9
80-380	Philosophy of Language	9

	Units	
Psychology		
85-375	Crosscultural Psychology	9
85-421	Language and Thought	9

	Units	
Social and Decision Science		
88-384	Conflict and Conflict Resolution in International Relations	9
88-391	Technology and Economic Growth	9
88-410	The Global Economy: A User's Guide	9
88-411	Rise of the Asian Economies	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9

5. Oral Proficiency Interview

Complete an oral proficiency interview. At the latest, this exam should be scheduled by midterm of the senior spring semester. Students are permitted to retake the test.

Study Abroad

A semester or year of study abroad is strongly recommended. Consult with your advisor and the Office of International Education (OIE) about possible options.

Senior Honors Thesis

Modern Languages majors are encouraged to undertake a Senior Honors Thesis (*Modern Languages Honors Thesis*, 82-591/82-592 or Dietrich College *Senior Honors Thesis I, II*, 66-501/66-502). The Honors Thesis program provides qualified seniors with a valuable opportunity to combine their academic and personal experiences and interests into a unique research project. (Prerequisites: a 3.5 QPA in Chinese and a 3.25 QPA overall)

Chinese Studies (B.A.) Sample Curriculum

This sample curriculum assumes that all prerequisites for 82-331 are fulfilled prior to the junior year.

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
82-331 Advanced Chinese I	82-332 Advanced Chinese II	Core Chinese Studies Elective From List A	Core Chinese Studies Elective From List A
82-333 Introduction to Chinese Language and Culture (12 units)	Core History and Society Elective	Chinese Studies Elective From List B	82-580 Senior Seminar in Modern Languages
Modern Languages core course or equivalent approved by advisor	Chinese Studies Elective From List B or Interdisciplinary Elective From List C	Chinese Studies Elective From List B or Interdisciplinary Elective From List C	Elective
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

This is presented as a two-year (junior-senior) plan for completing the major requirements. It is intended to show that this program can be completed in as few as two years, not that it must be. Students may enter their major and begin major course requirements as early as the start of the sophomore year, and in some instances in the first year. Students should consult their advisor when planning their program.

This plan is also an example of the suggested sequence of study for students who have had little or no prior exposure to the language. Such students would need to satisfy the prerequisites (elementary and intermediate language study) during their freshman and sophomore years.

The Major in French and Francophone Studies 93 units

Faculty Advisor

Dr. Bonnie Youngs, Teaching Professor of French and Francophone Studies (byoungs@cmu.edu)

Prerequisites

Intermediate-level proficiency in French. This is equivalent to the completion of four courses (two at the 100-level and two at the 200-level) or exemption based on Advanced Placement, International Baccalaureate or Carnegie Mellon internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all majors. (Study abroad advisor: Dr. Michael West, mjwest@andrew.cmu.edu)

Students may double count a maximum of one course taken for the French & Francophone Studies major that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in French and Francophone Studies 27 units

Complete all three courses.

	Units
82-303 Introduction to French Culture	9
82-304 The Francophone World	9
82-305 French in its Social Contexts	9

2. Core Courses in Modern Languages 12 units

Complete one 9 unit course* plus the Senior Seminar (3 units) in the spring of the senior year.

	Units
82-280 Learning About Language Learning	9
82-281 Tutoring for Community Outreach	Var.
82-282 Community Service Learning	Var.
82-283 Language, Diversity, & Cultural Identity	9
82-358 Literacies Across Language and Culture	9
82-383 Second Language Acquisition: Theories and Research	9
82-388 Understanding Second Language Fluency	9
82-480 Social and Cognitive Aspects of Bilingualism	9
82-580 Senior Seminar in Modern Languages	3

* In consultation with the major advisor, students may substitute a Modern Languages course elective with one related to language analysis, language learning, or acquisition of language and culture from the listings in French & Francophone Studies or from another department. Examples: 80-180 Nature of Language, 85-421 Language and Thought.

3. French and Francophone Studies Interdisciplinary Electives 54 units

Complete six courses (54 units) from List A or five courses (45 units) from List A and one (9 units) from List B.

List A. French and Francophone Electives

	Units
82-404 Francophone Realities *	9
82-415/416 Topics in French and Francophone Studies *	9
82-501/502 Special Topics: French and Francophone Studies	Var.
82-505 Undergraduate Internship	Var.

* Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their major advisor for the most up to date interdisciplinary electives appropriate for the French & Francophone Studies curriculum. Courses may be suggested to the major advisor for approval as a substitute. Note that not all courses are offered each semester.

Architecture		Units
48-338	European Cities in the XIX Century: Planning, Architecture, Preservation	9
48-340	Modern Architecture and Theory 1900-1945	9
48-341	Expression in Architecture	9
48-448	History of Sustainable Architecture	9
English		Units
76-239	Introduction to Film Studies	9
76-318	Communicating in the Global Marketplace	9
76-385	Introduction to Discourse Analysis	9
76-386	Language & Culture	9
76-387	Narrative & Argument	9
History		Units
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-258	French History: From the Revolution to De Gaulle	9
79-275	Introduction to Global Studies	9
79-350	Early Christianity	9
79-353	Religious Identities and Religious Conflicts in 19th Century Europe	9
79-385	The Making of the African Diaspora	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
79-396	Music and Society in 19th and 20th Century Europe and the U.S.	9
Modern Languages		Units
82-227	Germany & the European Union	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
Music		Units
57-173	Survey of Western Music History	9
57-306	World Music	6
57-441	Analysis of 19th Century Music	9
Philosophy		Units
80-180	Nature of Language	9
80-247	Ethics and Global Economics	9
80-280	Linguistic Analysis	9

80-281	Language and Thought	9
80-282	Phonetics and Phonology I	9
80-380	Philosophy of Language	9
80-381	Meaning in Language	9
Psychology		Units
85-375	Crosscultural Psychology	9
85-421	Language and Thought	9
Social and Decision Sciences		Units
88-384	Conflict and Conflict Resolution in International Relations	9
88-391	Technology and Economic Growth	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9
88-419	Negotiation	9

4. Oral Proficiency Interview

Complete an oral proficiency interview. At the latest, this exam should be scheduled by midterm of the senior spring semester. Students are permitted to retake the test.

Study Abroad

A semester or year of study abroad or internship is strongly recommended. Consult with your advisor and the Office of International Education (OIE) about possible options.

Senior Honors Thesis

Modern Languages majors are encouraged to undertake a Senior Honors Thesis (*Modern Languages Honors Thesis*, 82-591/82-592 or Dietrich College *Senior Honors Thesis I, II*, 66-501/66-502). The Honors Thesis program provides qualified seniors with a valuable opportunity to combine their academic and personal experiences and interests into a unique research project. (Prerequisites: a 3.5 QPA in French and a 3.25 QPA overall)

French and Francophone Studies (B.A.)

Sample Curriculum

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
82-303 Introduction to French Culture	82-305 French in its Social Contexts	French & Francophone Studies (FFS) Elective From List A	FFS Elective From List A
82-304 The Francophone World	Interdisciplinary Elective From List B	FFS Elective From List A	FFS Elective From List A
Modern Languages core course or equivalent approved by advisor	Elective	FFS Elective From List A	82-580 Senior Seminar in Modern Languages
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

This is presented as a two-year (junior-senior) plan for completing the major requirements. It is intended to show that this program can be completed in as few as two years, not that it must be. Students may enter their major and begin major course requirements as early as the start of the sophomore year, and in some instances in the first year. Students should consult their advisor when planning their program.

This plan is also an example of the suggested sequence of study for students who have had little or no prior exposure to the language. Such students would need to satisfy the prerequisites (elementary and intermediate language study) during their freshman and sophomore years.

The Major in German Studies 93 units

Faculty Advisor

Dr. Stephen Brockmann, Professor of German Studies (smb@andrew.cmu.edu)

Prerequisites

Intermediate-level proficiency in German. This is equivalent to the completion of four courses (two at the 100-level and two at the 200-level) or exemption based on Advanced Placement, International Baccalaureate or Carnegie Mellon internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended

for all majors. (Study abroad advisor: Dr. Gabriele Eichmanns Maier, eichgabi@andrew.cmu.edu)

Students may double count a maximum of one course taken for the German Studies major that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in German Studies 27 units

Complete all three courses.*

82-320	Contemporary Society in Germany, Austria and Switzerland	9
82-323	Germany, Austria and Switzerland in the 20th Century	9
82-327	The Emergence of the German Speaking World	9

* A 400-level course may be substituted with the major advisor's approval.

2. Core Courses in Modern Languages 12 units

Complete one 9-unit course* in Modern Languages, plus the senior seminar (3 units) in spring of the senior year.

82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
82-580	Senior Seminar in Modern Languages	3

* In consultation with the major advisor, students may substitute a Modern Languages course elective with one related to language analysis, language learning, or acquisition of language and culture from the listings in German Studies or from another department. Examples: 80-180 Nature of Language, 85-421 Language and Thought.

3. German Studies and Interdisciplinary Electives 54 units

Complete five courses (45 units) from List A and one (9 units) from List B, or a minimum of three courses (27 units) from List A and one or two courses (9-18 units) from List B. The student may complete an additional 3 units of coursework in German to allow a List B elective to count as a List A elective, with permission of the major advisor and the course instructor.

List A. German Electives

82-420	German Classical Literature	9
82-421	German Literature of the Nineteenth Century	9
82-422	German Literature of the Early Twentieth Century	9
82-425/426	Topics in German Literature and Culture *	9
82-427	Nazi and Resistance Culture	9
82-428	History of German Film	9
82-505	Undergraduate Internship	Var.
82-521/522	Special Topics: German Studies *	Var.

* Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

From possibilities such as but not limited to the following. Students should consult OLR and their major advisor for the most up to date interdisciplinary electives appropriate for the German Studies curriculum. Courses may be suggested to the major advisor for approval as a substitute. Note that not all courses are offered each semester.

Architecture		Units
48-338	European Cities in the XIX Century: Planning, Architecture, Preservation	9
48-340	Modern Architecture and Theory 1900-1945	9
48-350	Postwar Modern Architecture and Theory	9
English		Units
76-239	Introduction to Film Studies	9
76-386	Language & Culture	9

76-387	Narrative & Argument	9
76-483	Corpus Analysis in Rhetoric	9
History		Units
79-205	20th Century Europe	9
79-256	20th Century Germany	9
79-257	Germany and the Second World War	9
79-349	The Holocaust in Historical Perspective	9
Modern Languages		Units
82-227	Germany & the European Union	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-427	Nazi and Resistance Culture (when taken entirely in English)	9
82-428	History of German Film (when taken entirely in English)	9
82-480	Social and Cognitive Aspects of Bilingualism	9
Music		Units
57-306	World Music	6
Philosophy		Units
80-136	Social Structure, Public Policy & Ethics	9
80-180	Nature of Language	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-256	Modern Moral Philosophy	9
80-275	Metaphysics	9
80-280	Linguistic Analysis	9
80-380	Philosophy of Language	9
Psychology		Units
85-375	Crosscultural Psychology	9
85-421	Language and Thought	9

4. Oral Proficiency Interview

Complete an oral proficiency interview. At the latest, this exam should be scheduled by midterm of the senior spring semester. Students are permitted to retake the test.

Study Abroad

A semester or year of study abroad is strongly recommended. Consult with your advisor and the Office of International Education (OIE) about possible options.

Senior Honors Thesis

Modern Languages majors are encouraged to undertake a Senior Honors Thesis (*Modern Languages Honors Thesis*, 82-591/82-592 or Dietrich College *Senior Honors Thesis I, II*, 66-501/66-502). The Honors Thesis program provides qualified seniors with a valuable opportunity to combine their academic and personal experiences and interests into a unique research project. (Prerequisites: a 3.5 QPA in German and a 3.25 QPA overall)

German Studies (B.A.) Sample Curriculum

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
82-320 Contemporary Society in Germany, Austria and Switzerland	82-323 Germany, Austria and Switzerland in the 20th Century	German Studies Elective From List A	German Studies Elective From List A
82-327 The Emergence of the German Speaking World	Interdisciplinary Elective From List B	German Studies Elective From List A	German Studies Elective From List A or Interdisciplinary Elective From List B
Modern Languages core course or equivalent approved by advisor	Elective	German Studies Elective From List A or Interdisciplinary Elective From List B	82-580 Senior Seminar in Modern Languages
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

This is presented as a two-year (junior-senior) plan for completing the major requirements. It is intended to show that this program can be completed in as few as two years, not that it must be. Students may enter their major and begin major course requirements as early as the start of the sophomore year, and in some instances in the first year. Students should consult their advisor when planning their program.

This plan is also an example of the suggested sequence of study for students who have had little or no prior exposure to the language. Such students would need to satisfy the prerequisites (elementary and intermediate language study) during their freshman and sophomore years.

The Major in Hispanic Studies 93 units

Faculty Advisor

Dr. Therese Tardio, Associate Teaching Professor of Hispanic Studies (tardio@andrew.cmu.edu)

Prerequisites

Intermediate-level proficiency in Spanish. This is equivalent to the completion of four courses (two at the 100-level and two at the 200-level) or exemption based on Advanced Placement, International Baccalaureate or Carnegie Mellon internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all majors. (Study abroad advisor: Dr. Therese Tardio, tardio@andrew.cmu.edu)

Students may double count a maximum of one course taken for the Hispanic Studies major that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in Hispanic Studies 27 units

Complete two courses.

		Units
82-342	Spain: Language and Culture	9
82-343	Latin America: Language and Culture	9
82-344	U.S. Latinos: Language and Culture	9

Complete required course.

		Units
82-345	Introduction to Hispanic Literary and Cultural Studies	9

2. Core Courses in Modern Languages 12 units

Complete one 9-unit course* in Modern Languages, plus the senior seminar (3 units) in spring of the senior year.

		Units
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
82-580	Senior Seminar in Modern Languages	3

* In consultation with the major advisor, students may substitute a Modern Languages course elective with one related to language analysis, language

learning, or the acquisition of language and culture from the listings in Hispanic Studies or from another department. Examples: 80-180 Nature of Language, 85-421 Language and Thought.

3. Hispanic Studies and Interdisciplinary Electives 54 units

Complete six courses (54 units) from or five courses (45 units) from List A and one (9 units) from List B.

List A. Hispanic Studies Electives

	Units
82-441 Studies in Peninsular Literature and Culture *	9
82-442 Analysis of Spoken Spanish	9
82-443 Spanish Reading and Translation Workshop	9
82-444 The Structure of Spanish	9
82-451 Studies in Latin American Literature and Culture	9
82-455/456 Topics in Hispanic Studies *	9
82-506 Hispanic Studies Internship	Var.
82-541/542 Special Topics: Hispanic Studies *	Var.

* Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

From possibilities such as but not limited to the following. Students should consult OLR and their major advisor for the most up to date interdisciplinary electives appropriate for the Hispanic Studies curriculum. Courses may be suggested to the major advisor for approval as a substitute. Note that not all courses are offered each semester.

Architecture	Units
48-348 Architectural History of Mexico & Guatemala	9
English	Units
76-385 Introduction to Discourse Analysis	9
76-386 Language & Culture	9
76-387 Narrative & Argument	9
76-484 Discourse Analysis	9
History	Units
79-221 Development and Democracy in Latin America	9
79-222 Between Revolutions: The Development of Modern Latin America	9
79-223 Mexico: From the Aztec Empire to the Drug War	9
79-224 Mayan America	9
79-235 Caribbean Cultures	9
79-237 Comparative Slavery	9
79-254 The Jewish Diaspora in Latin America	9
79-272 Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-276 Beyond the Border	6
79-278 Rights to Representation: Indigenous People and their Media	9
79-288 Bananas, Baseball, and Borders: Latin America and the United States	9
79-295 Race Relations in the Atlantic World	9
Modern Languages	Units
82-280 Learning About Language Learning	9
82-281 Tutoring for Community Outreach	Var.
82-282 Community Service Learning	Var.
82-283 Language, Diversity, & Cultural Identity	9
82-358 Literacies Across Language and Culture	9
82-383 Second Language Acquisition: Theories and Research	9
82-388 Understanding Second Language Fluency	9
82-480 Social and Cognitive Aspects of Bilingualism	9
Music	Units
57-306 World Music	6
Philosophy	Units
80-180 Nature of Language	9
80-280 Linguistic Analysis	9
80-285 Natural Language Syntax	9

80-286 Words and Word Formation: Introduction to Morphology	9
80-380 Philosophy of Language	9
80-381 Meaning in Language	9
Psychology	Units
85-375 Crosscultural Psychology	9
85-421 Language and Thought	9

4. Oral Proficiency Interview

Complete an oral proficiency interview. At the latest, this exam should be scheduled by midterm of the senior spring semester. Students are permitted to retake the test.

Study Abroad

A semester or year of study abroad is strongly recommended. Consult with your advisor and the Office of International Education (OIE) about possible options.

Senior Honors Thesis

Modern Languages majors are encouraged to undertake a Senior Honors Thesis (*Modern Languages Honors Thesis*, 82-591/82-592 or Dietrich College *Senior Honors Thesis I, II*, 66-501/66-502). The Honors Thesis program provides qualified seniors with a valuable opportunity to combine their academic and personal experiences and interests into a unique research project. (Prerequisites: a 3.5 QPA in Hispanic Studies and a 3.25 QPA overall)

Hispanic Studies (B.A.)

Sample Curriculum

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
82-342 Spain: Language and Culture	82-345 Introduction to Hispanic Literary and Cultural Studies	Hispanic Studies Elective From List A	Hispanic Studies Elective From List A
82-343 Latin America: Language and Culture	Interdisciplinary Elective From List B	Hispanic Studies Elective From List A	Hispanic Studies Elective From List A
Modern Languages core course or equivalent approved by advisor	Elective	Hispanic Studies Elective From List A or Interdisciplinary Elective from List A or List B	82-580 Senior Seminar in Modern Languages
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

This is presented as a two-year (junior-senior) plan for completing the major requirements. It is intended to show that this program can be completed in as few as two years, not that it must be. Students may enter their major and begin major course requirements as early as the start of the sophomore year, and in some instances in the first year. Students should consult their advisor when planning their program.

This plan is also an example of the suggested sequence of study for students who have had little or no prior exposure to the language. Such students would need to satisfy the prerequisites (elementary and intermediate language study) during their freshman and sophomore years

The Major in Japanese Studies 102-105 units

Faculty Advisors

Dr. Yasufumi Iwasaki, Associate Teaching Professor of Japanese Studies (yiwasaki@andrew.cmu.edu)

Dr. Keiko Koda, Professor of Japanese Studies and Second Language Acquisition (kkoda@andrew.cmu.edu)

Prerequisites

Intermediate-level proficiency in the Japanese language. This is equivalent to the completion of three courses (two at the 100-level and one at the 200-level), or placement or exemption based on Advanced Placement, Cambridge GCE Advanced level, International Baccalaureate or CMU internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all majors. (Study abroad advisor - Dr. Yasufumi Iwasaki, yiwasaki@andrew.cmu.edu)

Students may double count a maximum of one course taken for the Japanese Studies major that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in Japanese Studies 36–39 units

Complete all four courses.

	Units
82-272 Intermediate Japanese II *	12
82-273 Introduction to Japanese Language and Culture	9
82-371 Advanced Japanese I	9
82-372 Advanced Japanese II	9

* Students who place out of 82-272 Intermediate Japanese II must take 9 units chosen from List A electives.

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2. Core Courses in Modern Languages 12 units

Complete one 9-unit course* in Modern Languages, plus the senior seminar (3 units) in spring of the senior year.

	Units
82-280 Learning About Language Learning	9
82-281 Tutoring for Community Outreach	Var.
82-282 Community Service Learning	Var.
82-283 Language, Diversity, & Cultural Identity	9
82-358 Literacies Across Language and Culture	9
82-383 Second Language Acquisition: Theories and Research	9
82-388 Understanding Second Language Fluency	9
82-480 Social and Cognitive Aspects of Bilingualism	9
82-580 Senior Seminar in Modern Languages	3

* In consultation with the major advisor, students may substitute a Modern Languages course elective with one related to language analysis, language learning, or the acquisition of language and culture from the listings in Japanese Studies or from another department. Examples: 80-180 Nature of Language, 85-421 Language and Thought.

3. Japanese Studies and Interdisciplinary Electives 54 units

Complete four courses (36 units) from List A and two (18 units) from List B. With permission of the major advisor, students are encouraged to complete at least one Japanese history course that qualifies for List A or List B at the University of Pittsburgh, one in Japan when they study abroad, or in a summer program at any other university.

List A. Japanese Electives

	Units
82-373 Structure of the Japanese Language	9
82-374 Technical Japanese	9
82-473/474 Topics in Japanese Studies *	9
82-476 Japanese Discourse Analysis	9
82-505 Undergraduate Internship	Var.
82-571/572 Special Topics: Japanese Studies *	Var.

* Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their major advisor for the most up to date interdisciplinary electives appropriate for the Japanese Studies curriculum. Courses may be suggested to the major advisor for approval as a substitute. Note that not all courses are offered each semester.

English	Units
76-239 Introduction to Film Studies	9
76-386 Language & Culture	9
76-387 Narrative & Argument	9
History	Units
79-261 Chinese Culture and Society	9
79-262 Modern China	9
79-275 Introduction to Global Studies	9
79-211 East Asia in the World, 1600-Present	9
Modern Languages	Units
82-234 Topics in Chinese History	9
82-278 Japanese Film and Literature: The Art of Storytelling	9
82-280 Learning About Language Learning	9

82-281 Tutoring for Community Outreach	Var.
82-282 Community Service Learning	Var.
82-283 Language, Diversity, & Cultural Identity	9
82-358 Literacies Across Language and Culture	9
82-373 Structure of the Japanese Language	9
82-374 Technical Japanese	9
82-383 Second Language Acquisition: Theories and Research	9
82-388 Understanding Second Language Fluency	9
82-480 Social and Cognitive Aspects of Bilingualism	9

Music	Units
57-306 World Music	6

Philosophy	Units
80-180 Nature of Language	9
80-280 Linguistic Analysis	9
80-380 Philosophy of Language	9

Psychology	Units
85-375 Crosscultural Psychology	9
85-421 Language and Thought	9

Social and Decision Sciences	Units
88-384 Conflict and Conflict Resolution in International Relations	9

4. Oral Proficiency Interview

Complete an oral proficiency interview. At the latest, this exam should be scheduled by midterm of the senior spring semester. Students are permitted to retake the test.

Study Abroad

A semester or year of study abroad is strongly recommended. Consult with your advisor and the Office of International Education (OIE) about possible options.

Senior Honors Thesis

Modern Languages majors are encouraged to undertake a Senior Honors Thesis (*Modern Languages Honors Thesis*, 82-591/82-592 or Dietrich College *Senior Honors Thesis I, II*, 66-501/66-502). The Honors Thesis program provides qualified seniors with a valuable opportunity to combine their academic and personal experiences and interests into a unique research project. (Prerequisites: a 3.5 QPA in Japanese Studies and a 3.25 QPA overall)

Japanese Studies (B.A.) Sample Curriculum

This sample curriculum assumes that all prerequisites for 82-371 are fulfilled prior to the junior year.

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
82-273 Introduction to Japanese Language and Culture	82-372 Advanced Japanese II	Japanese Studies Elective from List A	Japanese Studies Elective From List A
82-371 Advanced Japanese I	Modern Languages core course of equivalent approved by advisor	Japanese Studies Elective from List A	Interdisciplinary Elective From List B
Modern Languages core course of equivalent	Interdisciplinary Elective from List B	Elective	82-580 Senior Seminar in Modern Languages
Elective	Interdisciplinary Elective from List B	Elective	Elective
Elective	Elective	Elective	Elective
	Elective		

This is presented as a two-year (junior-senior) plan for completing the major requirements. It is intended to show that this program can be completed in as few as two years, not that it must be. Students may enter their major and begin major course requirements as early as the start of the sophomore year, and in some instances in the first year. Students should consult their advisor when planning their program.

This plan is also an example of the suggested sequence of study for students who have had little or no prior exposure to the language. Such students would need to satisfy the prerequisites (elementary and intermediate language study) during their freshman and sophomore years.

The Major in Russian Studies 75–78 units

Faculty Advisor

Dr. Charlene Castellano, Teaching Professor of Russian
(cc62@andrew.cmu.edu)

The major in Russian Studies is jointly administered by the Departments of History and Modern Languages. Students are required to fulfill requirements in history and in language and culture.

Prerequisites

Elementary-level proficiency in the Russian language. This is equivalent to the completion of two courses at the 100-level, or placement or exemption based on Advanced Placement, International Baccalaureate or CMU internal placement test scores. Carnegie Mellon students who arrive with previous language study and/or who have high AP or CEEB scores will be able to begin taking courses toward the major earlier in their undergraduate program and will also be able, should they so desire, to complete an additional major. In all cases, progress will be accelerated by study abroad, which is highly recommended for all majors. (Study abroad advisor - Dr. Charlene Castellano, cc62@andrew.cmu.edu)

Students may double count a maximum of one course taken for the Russian Studies major that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Course in History 9 units

Complete one course.*

79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9

* Both courses are recommended.

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2. Required Electives in History 18 units

Complete two courses. In consultation with the major advisor, students may substitute a different course. Units

79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-341	The Cold War in Documents and Film	9

3. Core Courses in Modern Languages 27 units

Complete three courses.

82-291	Intermediate Russian I	9
82-292	Intermediate Russian II	9
82-399	Special Topics: Russian in Context (Students can repeat 82-399 with different topics.)	Var.

Should a student enter the Russian Studies program with demonstrated language proficiency at the intermediate or advanced level, higher level courses will be used to complete the required total of 27 units from the list of core courses in Modern Languages. Advanced language options include *Special Topics: Russian*, a repeatable course, as well as subject-oriented language supplements to existing courses taught in English in a variety of fields. The student can add a language supplement (3 units) to selected 9-unit electives, earning a total of 12 units for the language-supplemented course.

4. Required Electives 18 units

Complete two courses. This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their major advisor for the most up to date interdisciplinary electives appropriate for the Russian Studies curriculum. Courses may be suggested to the major advisor for approval as a substitute. Note that not all courses are offered each semester.

History

79-205	20th Century Europe	9
79-231	American Foreign Policy: 1945-Present	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9

79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-341	The Cold War in Documents and Film	9

Modern Languages

82-283	Language, Diversity, & Cultural Identity	9
82-294	Topics in Russian Language and Culture *	Var.
82-296	A Century of Russian Film	9
82-396	The Faust Legend at Home and Abroad (or 82-193 which is a Freshman Seminar.)	Var.
82-397	Russia's Demons	Var.
82-399	Special Topics: Russian in Context *	Var.
82-400	Russian Studies Topics (section A and/or B)	6
82-491	Topics in Twentieth-Century Russian Literature *	Var.
82-492	The Historical Imagination in Nineteenth-Century Russian Literature	Var.
82-505	Undergraduate Internship	Var.
82-580	Senior Seminar in Modern Languages **	3

*Students may repeat these courses with new topics.

**If their schedule permits and after consultation with the major advisor, students may elect to take the 3-unit Modern Languages Senior Seminar in addition to two 9-unit electives.

5. Required Independent Research 3–6 units

Complete one course.	Units	
82-599	Russian Studies Thesis	Var.

In the senior year, majors are required to undertake an independent research or translation project in which their language skills are applied to Russian-language materials. This project, which earns 3 to 6 units, is conducted in connection with an existing course in Russian history, language, literature or politics. The student works closely with the professor to select a topic requiring the use of Russian sources suitable to the student's proficiency level. For example, students may choose to prepare a translation of a little-known piece of Russian literature or a debate from a nineteenth-century journal, to compare Soviet and Western newspaper coverage of the Cuban missile crisis, to research Russian opinion of American race relations, or to read and evaluate the reviews of a popular Russian novel.

Study Abroad

Students in both the major and minor programs are encouraged to spend a semester or summer in Russia via an approved exchange program. Many exchange programs offer instruction in Russian language, history, literature, and culture, in internationally recognized universities. They also offer travel to ancient sites and cities, visits to museums, palaces, exhibitions, and monuments, and the opportunity to live with a Russian host family. Scholarship monies are available.

Faculty Exchange Program

In 1993, the College of Humanities and Social Sciences initiated a faculty exchange program with the Russian State University of the Humanities (RGGU), one of the foremost universities in Russia, located in Moscow. Carnegie Mellon has hosted faculty members from RGGU specializing in history, language and philosophy. These professors have joined our College departments for a semester, offering unique courses and perspectives not generally available to our students. In the past, these Russian visitors have offered courses on the Russian Civil War as well as advanced language and literature courses. Several faculty members from Carnegie Mellon have visited Moscow, using the RGGU exchange to pursue archival research and collaborative projects. The exchange offers students an opportunity to study language from native speakers, gain exposure to different perspectives on history and politics, and gather firsthand knowledge about recent developments in Russia. In addition, the exchange can provide important contacts for students interested in pursuing careers abroad.

Sample Curriculum - Russian Studies, B.A.

This sample curriculum assumes that all prerequisites for 82-291 are fulfilled prior to the junior year.

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
82-291 Intermediate Russian I	82-292 Intermediate Russian II	82-399 Special Topics: Russian in Context	82-599 Russian Studies Thesis
Core Course in History 76-265/266	Required Elective in History	82-399 Special Topics: Russian in Context	Required Elective
Elective	Required Elective	Required Elective	82-580 Senior Seminar in Modern Languages
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

This is presented as a two-year (junior-senior) plan for completing the major requirements. Its purpose is to show that this program can be completed in as few as two years, not that it must be. Students may enter their major and begin major course requirements as early as the start of the sophomore year, and in some instances in the first year. Students should consult their advisor when planning their program.

This plan is also an example of the suggested sequence of study for students who have had little or no prior exposure to the language. Such students would need to satisfy the prerequisites (elementary and intermediate language study) during their freshman and sophomore years.

Modern Languages as an Additional Major

In addition to their primary major, a student may complete a major in Chinese Studies, French and Francophone Studies, German Studies, Hispanic Studies, Japanese Studies, and Russian Studies. Students outside of Dietrich College interested in an additional major in Modern Languages need to fulfill only the requirements for the Modern Languages major but not the Dietrich College General Education requirements.

Minors in the Department of Modern Languages

The Department of Modern Languages also offers minors in Chinese Studies, French and Francophone Studies, German Studies, Hispanic Studies, Japanese Studies, and Russian Studies. A minor in one of these language and culture areas requires core courses similar to the major and includes a variety of options for electives. Many students study abroad as part of their program. Students who minor in Modern Languages have found the program an enriching complement to their major areas of study and an asset to their work in government, entrepreneurship and business, law, technology and engineering firms, media, public health, health policy, and health professions, non-profit organizations, entertainment and creative arts, and education.

Curriculum

The minimum requirement for the minor in French and Francophone Studies, German Studies or Hispanic Studies is 54 units (not including any 100- or 200-level prerequisite work in the chosen language), as outlined below. The minimum requirement for the minor in Chinese Studies, Japanese Studies or Russian Studies is 54-60 units, depending on the student's language background.

Language-specific faculty advisors for these specializations are:

Chinese Studies-Dr. Gang Liu, Assistant Teaching Professor of Chinese Studies, Dr. Sue-mei Wu, Teaching Professor of Chinese Studies, and Tianxue Yao, Lecturer of Chinese Studies

French & Francophone Studies- Dr. Bonnie Youngs, Teaching Professor of French & Francophone Studies

German Studies-Dr. Gabriele Eichmanns Maier, Associate Teaching Professor of German Studies

Hispanic Studies-Dr. Felipe Gómez, Associate Teaching Professor of Hispanic Studies and Dr. María del Mar Rosa Rodríguez, Assistant Professor of Hispanic Studies

Japanese Studies- Dr. Yasufumi Iwasaki, Associate Teaching Professor of Japanese and Dr. Yoshihiro Yasuhara, Assistant Teaching Professor of Japanese Studies

Russian Studies-Dr. Charlene Castellano, Teaching Professor of Russian

The Minor in Chinese Studies 57-60 units

Faculty Advisors

Dr. Gang Liu, Assistant Teaching Professor of Chinese Studies (gangliu@andrew.cmu.edu)

Dr. Sue-mei Wu, Teaching Professor of Chinese Studies (suemei@andrew.cmu.edu)

Tianxue Yao, Lecturer of Chinese Studies (tyao@andrew.cmu.edu)

Prerequisites

Intermediate-level proficiency in the Chinese language. This is equivalent to the completion of three courses (two at the 100-level and one at the 200-level), or placement or exemption based on Advanced Placement, International Baccalaureate or CMU internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all minors. (Study abroad advisor - Dr. Yueming Yu, yyu@andrew.cmu.edu).

Students may double count a maximum of one course taken for the Chinese Studies minor that is also being used to fulfill the requirements of other majors, minors, and programs.

Students with native or near-native proficiency in listening and speaking of the language prior to entering CMU should consult with the minor advisors for a different curriculum that may accelerate their completion of the requirement.

1. Core Courses in Chinese Studies 36-39 units

Complete four courses.

82-232	Intermediate Chinese II (may be substituted by 82-235 Intermediate Chinese for Heritage Students)	12
82-235	Intermediate Chinese for Heritage Students *	12
82-331	Advanced Chinese I	9
82-332	Advanced Chinese II	9
82-333	Introduction to Chinese Language and Culture **	Var.

*Students who place out of 82-232/82-235 must take a minimum of 9 additional units chosen from List A Electives.

**Students must take this course for 12 units with the additional work in Chinese to fulfill the requirement. Students who take this course for 9 units prior to declaring their minor must register for 3 units of independent study later in their studies.

2. Chinese Studies and Interdisciplinary Electives 18 units

List A. Chinese Studies Electives

Complete two courses (18 units) from List A or one course (9 units) from List A and one (9 units) from List B.

82-334	Structure of Chinese	9
82-335	Readings in Chinese	9
82-337	Mandarin Chinese for Oral Communication I	9
82-338	Mandarin Chinese for Oral Communication II	9
82-339	Business Language & Culture in China I	9
82-340	Business Language & Culture in China II	9
82-432	Popular Culture in China	9
82-433	Topics in Contemporary Culture of China *	9
82-440	Studies in Chinese Literature & Culture *	9
82-432	Popular Culture in China	9
82-433	Topics in Contemporary Culture of China *	9
82-434	Studies in Chinese Traditions *	9
82-436	Introduction to Classical Chinese *	9
82-439	Modern China Through Literature *	9
82-440	Studies in Chinese Literature & Culture *	9
82-505	Undergraduate Internship	Var.
82-531/532	Special Topics in Chinese Studies *	Var.

*Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their minor advisor for the most up to date interdisciplinary electives appropriate for the Chinese Studies curriculum. Courses may be suggested to the minor advisor for approval as a substitute. Note that not all courses are offered each semester.

Architecture		Units
48-351	Human Factors in Architecture	9
48-551	Ethics and Decision Making in Architecture	9
Art		Units
60-373	Aesthetics from a Global Viewpoint	9
60-399	Art History/Theory Independent Study	9
Business Administration		Units
70-342	Managing Across Cultures	9
70-365	International Trade and International Law	9
70-430	International Management	9
English		Units
76-318	Communicating in the Global Marketplace	9
76-339	Topics in Film Studies	9
76-386	Language & Culture	9
76-387	Narrative & Argument	9
History		Units
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-309	20th Century China Through Film	9
Modern Languages		Units
82-230	Topics in Cultural Comparison	9
82-234	Topics in Chinese History	9
82-237	Topics in Traditional China	9
82-238	Topics in Chinese Culture	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
Philosophy		Units
80-180	Nature of Language	9
80-276	Philosophy of Religion	9
80-280	Linguistic Analysis	9
80-380	Philosophy of Language	9
Psychology		Units
85-375	Crosscultural Psychology	9
85-421	Language and Thought	9
Social and Decision Sciences		Units
88-384	Conflict and Conflict Resolution in International Relations	9
88-391	Technology and Economic Growth	9
88-410	The Global Economy: A User's Guide	9
88-411	Rise of the Asian Economies	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9

The Minor in French and Francophone Studies 54 units

Faculty Advisor

Dr. Bonnie Youngs, Teaching Professor of French and Francophone Studies (byoungs@cmu.edu)

Prerequisites

Intermediate-level proficiency in French. This is equivalent to the completion of four courses (two at the 100-level and two at the 200-level) or exemption based on Advanced Placement, International Baccalaureate or Carnegie Mellon internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all minors. (Study abroad advisor - Dr. Michael West, mjwest@andrew.cmu.edu (eichgabi@andrew.cmu.edu))

Students may double count a maximum of one course taken for the French & Francophone Studies minor that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in French and Francophone Studies 27 units

Complete three courses.

82-303	Introduction to French Culture	9
82-304	The Francophone World	9
82-305	French in its Social Contexts	9

2. French and Francophone Studies and Interdisciplinary Electives 27 units

Complete three courses (27 units) from List A, or two courses (18 units) from List A and one (9 units) from List B.

List A. French Electives

82-404	Francophone Realities *	Units 9
82-415/416	Topics in French and Francophone Studies *	9
82-501/502	Special Topics: French and Francophone Studies	Var.
82-505	Undergraduate Internship	Var.

* Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their minor advisor for the most up to date interdisciplinary electives appropriate for the French & Francophone Studies curriculum. Courses may be suggested to the minor advisor for approval as a substitute. Note that not all courses are offered each semester.

Architecture		Units
48-338	European Cities in the XIX Century: Planning, Architecture, Preservation	9
48-340	Modern Architecture and Theory 1900-1945	9
48-341	Expression in Architecture	9
48-448	History of Sustainable Architecture	9
English		Units
76-239	Introduction to Film Studies	9
76-318	Communicating in the Global Marketplace	9
76-385	Introduction to Discourse Analysis	9
76-386	Language & Culture	9
76-387	Narrative & Argument	9
History		Units
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-353	Religious Identities and Religious Conflicts in 19th Century Europe	9
79-385	The Making of the African Diaspora	9
79-258	French History: From the Revolution to De Gaulle	9
79-275	Introduction to Global Studies	9
79-350	Early Christianity	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
79-396	Music and Society in 19th and 20th Century Europe and the U.S.	9
Modern Languages		Units
82-227	Germany & the European Union	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-383	Second Language Acquisition: Theories and Research	9

82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
Music		Units
57-173	Survey of Western Music History	9
57-306	World Music	6
Philosophy		Units
80-180	Nature of Language	9
80-280	Linguistic Analysis	9
80-281	Language and Thought	9
80-380	Philosophy of Language	9
Psychology		Units
85-375	Crosscultural Psychology	9
85-421	Language and Thought	9
Social and Decision Sciences		Units
88-384	Conflict and Conflict Resolution in International Relations	9
88-391	Technology and Economic Growth	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9
88-419	Negotiation	9

The Minor in German Studies 54 units

Faculty Advisor

Dr. Gabriele Eichmanns Maier, Associate Teaching Professor of German Studies
(eichgabi@andrew.cmu.edu)

Prerequisites

Intermediate-level proficiency in German. This is equivalent to the completion of four courses (two at the 100-level and two at the 200-level) or exemption based on Advanced Placement, International Baccalaureate or Carnegie Mellon internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all minors. (Study abroad advisor - Dr. Gabriele Eichmanns Maier, eichgabi@andrew.cmu.edu)

Students may double count a maximum of one course taken for the German Studies minor that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in German Studies 27 units

Complete three courses.*

		Units
82-320	Contemporary Society in Germany, Austria and Switzerland	9
82-323	Germany, Austria and Switzerland in the 20th Century	9
82-327	The Emergence of the German Speaking World	9

* A 400-level course may be substituted with the minor advisor's approval.

2. German Studies & Interdisciplinary Electives 27 units

Complete three courses (27 units) from List A or two courses (18 units) from List A and one (9 units) from List B.

List A. German Studies Electives

		Units
82-420	German Classical Literature	9
82-421	German Literature of the Nineteenth Century	9
82-422	German Literature of the Early Twentieth Century	9
82-425/426	Topics in German Literature and Culture *	9
82-427	Nazi and Resistance Culture	9
82-428	History of German Film	9
82-521/522	Special Topics: German Studies *	Var.

*Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their minor advisor for the most

up to date interdisciplinary electives appropriate for the German Studies curriculum. Courses may be suggested to the minor advisor for approval as a substitute. Note that not all courses are offered each semester.

Architecture		Units
48-338	European Cities in the XIX Century: Planning, Architecture, Preservation	9
48-340	Modern Architecture and Theory 1900-1945	9
48-350	Postwar Modern Architecture and Theory	9
English		Units
76-239	Introduction to Film Studies	9
76-386	Language & Culture	9
76-387	Narrative & Argument	9
76-483	Corpus Analysis in Rhetoric	9
History		Units
79-205	20th Century Europe	9
79-257	Germany and the Second World War	9
79-349	The Holocaust in Historical Perspective	9
Modern Languages		Units
82-227	Germany & the European Union	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-383	Second Language Acquisition: Theories and Research	9
82-358	Literacies Across Language and Culture	9
82-388	Understanding Second Language Fluency	9
82-427	Nazi and Resistance Culture (when taken entirely in English)	9
82-428	History of German Film (when taken entirely in English)	Var.
82-480	Social and Cognitive Aspects of Bilingualism	9
Music		Units
57-306	World Music	6
Philosophy		Units
80-136	Social Structure, Public Policy & Ethics	9
80-180	Nature of Language	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-256	Modern Moral Philosophy	9
80-275	Metaphysics	9
80-280	Linguistic Analysis	9
80-380	Philosophy of Language	9
Psychology		Units
85-375	Crosscultural Psychology	9
85-421	Language and Thought	9

54 units The Minor in Hispanic Studies

The Minor in Hispanic Studies 54 units

Faculty Advisors

Dr. Felipe Gómez, Associate Teaching Professor of Hispanic Studies
(fgomez@andrew.cmu.edu)

Dr. María del Mar Rosa Rodríguez, Assistant Professor of Hispanic Studies
(mrosarod@andrew.cmu.edu)

Prerequisites

Intermediate-level proficiency in Spanish. This is equivalent to the completion of four courses (two at the 100-level and two at the 200-level) or exemption based on Advanced Placement, International Baccalaureate or Carnegie Mellon internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all minors. (Study abroad advisor - Dr. Therese Tardio, tardio@andrew.cmu.edu)

Students may double count a maximum of one course taken for the Hispanic Studies minor that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in Hispanic Studies 27 units

Complete two courses.

	Units
82-342 Spain: Language and Culture	9
82-343 Latin America: Language and Culture	9
82-344 U.S. Latinos: Language and Culture	9

Complete the following course.

	Units
82-345 Introduction to Hispanic Literary and Cultural Studies	9

2. Hispanic Studies and Interdisciplinary Electives 27 units

Complete three courses (27 units) from List A or two courses (18 units) from List A and one (9 units) from List B.

List A: Hispanic Studies Electives

	Units
82-441 Studies in Peninsular Literature and Culture *	9
82-442 Analysis of Spoken Spanish	9
82-443 Spanish Reading and Translation Workshop	9
82-444 The Structure of Spanish	9
82-451 Studies in Latin American Literature and Culture	9
82-455/456 Topics in Hispanic Studies *	9
82-505 Undergraduate Internship	Var.
82-541/542 Special Topics: Hispanic Studies *	Var.

* Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their minor advisor for the most up to date interdisciplinary electives appropriate for the Hispanic Studies curriculum. Courses may be suggested to the minor advisor for approval as a substitute. Note that not all courses are offered each semester.

Architecture	Units
48-348 Architectural History of Mexico & Guatemala	9
English	Units
76-385 Introduction to Discourse Analysis	9
76-484 Discourse Analysis	9
76-386 Language & Culture	9
76-387 Narrative & Argument	9
History	Units
79-221 Development and Democracy in Latin America	9
79-222 Between Revolutions: The Development of Modern Latin America	9
79-223 Mexico: From the Aztec Empire to the Drug War	9
79-224 Mayan America	9
79-235 Caribbean Cultures	9
79-237 Comparative Slavery	9
79-254 The Jewish Diaspora in Latin America	9
79-272 Iberian Encounters: Muslims, Christians, and Jews in Spain	9
79-276 Beyond the Border	6
79-278 Rights to Representation: Indigenous People and their Media	9
79-288 Bananas, Baseball, and Borders: Latin America and the United States	9
79-295 Race Relations in the Atlantic World	9
79-296 Perspectives on Social Protest	9
Modern Languages	Units
82-280 Learning About Language Learning	9
82-281 Tutoring for Community Outreach	Var.
82-282 Community Service Learning	Var.
82-283 Language, Diversity, & Cultural Identity	9
82-358 Literacies Across Language and Culture	9
82-383 Second Language Acquisition: Theories and Research	9

82-388 Understanding Second Language Fluency	9
82-480 Social and Cognitive Aspects of Bilingualism	9
Music	Units
57-306 World Music	6
Philosophy	Units
80-180 Nature of Language	9
80-280 Linguistic Analysis	9
80-285 Natural Language Syntax	9
80-286 Words and Word Formation: Introduction to Morphology	9
80-380 Philosophy of Language	9
80-381 Meaning in Language	9
Psychology	Units
85-375 Crosscultural Psychology	9
85-421 Language and Thought	9

The Minor in Japanese Studies 54–57 units

Faculty Advisors

Dr. Yasufumi Iwasaki, Associate Teaching Professor of Japanese (yiwasaki@andrew.cmu.edu)

Dr. Yoshihiro Yasuhara, Associate Teaching Professor of Japanese Studies (yyashuar@andrew.cmu.edu)

Prerequisites

Intermediate-level of proficiency in the Japanese language. This is equivalent to the completion of three courses (two at the 100-level and one at the 200-level), or placement or exemption based on Advanced Placement, Cambridge GCE Advanced level, International Baccalaureate or CMU internal placement test scores. In all cases, progress will be accelerated by study abroad, which is highly recommended for all minors. (Study abroad advisor - Dr. Yasufumi Iwasaki, yiwasaki@andrew.cmu.edu)

Students may double count a maximum of one course taken for the Japanese Studies minor that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Core Courses in Japanese Studies 27–39 units*

Complete four courses.

82-272 Intermediate Japanese II *	12
82-273 Introduction to Japanese Language and Culture	9
82-371 Advanced Japanese I	9
82-372 Advanced Japanese II	9

*Students who place out of 82-272 must take 9 units chosen from the List A electives.

2. Japanese Studies and Interdisciplinary Electives 18 units

Complete two courses (18 units) from List A, or one course (9 units) from List A and one (9 units) from List B.

List A. Japanese Studies Electives

82-373 Structure of the Japanese Language	9
82-374 Technical Japanese	9
82-473/474 Topics in Japanese Studies *	9
82-476 Japanese Discourse Analysis	9
82-505 Undergraduate Internship	Var.
82-571/572 Special Topics: Japanese Studies *	Var.

*Students may repeat these courses with new topics.

List B. Interdisciplinary Electives

This list is compiled from possibilities such as but not limited to the following. Students should consult OLR and their minor advisor for the most up to date interdisciplinary electives appropriate for the Japanese Studies curriculum. Courses may be suggested to the minor advisor for approval as a substitute. Note that not all courses are offered each semester.

English	
76-239 Introduction to Film Studies	9
76-386 Language & Culture	9
76-387 Narrative & Argument	9
History	

79-211	East Asia in the World, 1600-Present	9
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-275	Introduction to Global Studies	9
Modern Languages		
82-234	Topics in Chinese History	9
82-278	Japanese Film and Literature: The Art of Storytelling	9
82-280	Learning About Language Learning	9
82-281	Tutoring for Community Outreach	Var.
82-282	Community Service Learning	Var.
82-283	Language, Diversity, & Cultural Identity	9
82-358	Literacies Across Language and Culture	9
82-373	Structure of the Japanese Language	9
82-374	Technical Japanese	9
82-383	Second Language Acquisition: Theories and Research	9
82-388	Understanding Second Language Fluency	9
82-480	Social and Cognitive Aspects of Bilingualism	9
Music		
57-306	World Music	6
Philosophy		
80-180	Nature of Language	9
80-280	Linguistic Analysis	9
80-380	Philosophy of Language	9
Psychology		
85-375	Crosscultural Psychology	9
85-421	Language and Thought	9
Social and Decision Sciences		
88-384	Conflict and Conflict Resolution in International Relations	9

The Minor in Russian Studies 54 units

Faculty Advisor

Dr. Charlene Castellano, Teaching Professor of Russian
(cc62@andrew.cmu.edu)

The minor in Russian Studies is jointly administered by the Departments of History and Modern Languages. Students are required to fulfill requirements in history and in language and culture.

Prerequisites

Elementary-level proficiency in the Russian language. This is equivalent to the completion of two courses at the 100-level, or placement or exemption based on Advanced Placement, International Baccalaureate or CMU internal placement test scores. Carnegie Mellon students who arrive with previous language study and/or who have high AP or CEEB scores will be able to begin taking courses toward the minor earlier in their undergraduate program. In all cases, progress will be accelerated by study abroad, which is highly recommended for all minors. (Study abroad advisor - Dr. Charlene Castellano, cc62@andrew.cmu.edu)

Students may double count a maximum of one course taken for the Russian Studies minor that is also being used to fulfill the requirements of other majors, minors, and programs.

1. Required Course in History	9 units
Complete one course. *	Units
79-265 Russian History: From the First to the Last Tsar	9
79-266 Russian History: From Communism to Capitalism	9
* Both courses are recommended.	
2. Required Electives in History	18 units
In consultation with the minor advisor, students may choose a substitute.	Units
79-267 The Soviet Union in World War II: Military, Political, and Social History	9

79-341 The Cold War in Documents and Film	9
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3. Core Courses in Modern Languages 18 units

Complete both courses.	Units
82-291 Intermediate Russian I	9
82-292 Intermediate Russian II	9

Should a student enter the Russian Studies program with demonstrated language proficiency at the intermediate or advanced level, higher level courses will be used to complete the required total of 18 units of core courses in Modern Languages. Advanced language options include *Special Topics: Russian*, a repeatable course, as well as subject-oriented language supplements to existing courses taught in English in a variety of fields. The student can add a language supplement (3 units) to selected 9-unit electives, earning a total of 12 units for the language-supplemented course.

4. Interdisciplinary Electives 18 units

Complete two courses. This list is compiled from possibilities such as but not limited to the following. Students should consult their minor advisor for the most up to date interdisciplinary electives appropriate for the Russian Studies curriculum. Courses may be suggested to the minor advisor for approval as a substitute. Note that not all courses are offered each semester.

History	Units
79-205 20th Century Europe	9
79-231 American Foreign Policy: 1945-Present	9
79-265 Russian History: From the First to the Last Tsar	9
79-266 Russian History: From Communism to Capitalism	9
79-267 The Soviet Union in World War II: Military, Political, and Social History	9
79-341 The Cold War in Documents and Film	9

Modern Languages	Units
82-283 Language, Diversity, & Cultural Identity	9
82-294 Topics in Russian Language and Culture *	Var.
82-296 A Century of Russian Film	9
82-396 The Faust Legend at Home and Abroad	Var.
82-397 Russia's Demons	Var.
82-399 Special Topics: Russian in Context *	Var.
82-400 Russian Studies Topics (section A and/or B)	6
82-491 Topics in Twentieth-Century Russian Literature	9
82-492 The Historical Imagination in Nineteenth-Century Russian Literature	Var.

* Students may repeat these course with new topics.

Study Abroad

A semester or year of study abroad is strongly recommended. Consult with your advisor and the Office of International Education (OIE) about possible options. Students are encouraged to spend a semester or summer in Russia via an approved exchange program. Many exchange programs offer instruction in Russian language, history, literature, and culture, in internationally recognized universities. They also offer travel to ancient sites and cities, visits to museums, palaces, exhibitions, and monuments, and the opportunity to live with a Russian host family. Scholarship opportunities are available.

Faculty

MARIANA ACHUGAR, Associate Professor of Hispanic Studies & Second Language Acquisition - Ph.D., University of California at Davis; Carnegie Mellon, 2003-.

STEPHEN BROCKMANN, Professor of German with courtesy appointments in English and History - Ph.D., University of Wisconsin Madison; Carnegie Mellon, 1993-.

CHARLENE CASTELLANO, Teaching Professor of Russian with a courtesy appointment in English - Ph.D., Cornell University; Carnegie Mellon, 1990-.

ERIK HELIN, Special Lecturer, Carnegie Mellon - Qatar - MA, Eastern Michigan; Carnegie Mellon, 2006-.

ZEINAB IBRAHIM, Associate Teaching Professor, Carnegie Mellon - Qatar - Ph.D., Georgetown University; Carnegie Mellon, 2009-.

KENYA C. DWORKIN Y MENDEZ, Associate Professor of Hispanic Studies with courtesy appointments in English and History – Ph.D., University of California, Berkeley; Carnegie Mellon, 1993–.

GABRIELE EICHMANNS-MAIER, Associate Teaching Professor of German – Ph.D., University of Washington; Carnegie Mellon, 2008–.

BARBARA FREED, Professor Emeritus of French & Francophone Studies and Second Language Acquisition – Ph.D., University of Pennsylvania; Carnegie Mellon, 1990–.

FELIPE GOMEZ, Associate Teaching Professor of Hispanic Studies – Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2006–.

CHRISTIAN HALLSTEIN, Teaching Professor of German – Ph.D., Pennsylvania State University; Carnegie Mellon, 1979–.

PAUL HOPPER, Paul Mellon Distinguished Professor Emeritus of the Humanities, Rhetoric and Linguistics with a courtesy appointment in Modern Languages – Ph.D., University of Texas; Carnegie Mellon, 1990–.

YASUFUMI IWASAKI, Associate Teaching Professor of Japanese – Ph.D., University of Illinois; Carnegie Mellon, 2005–.

BARBARA JOHNSTONE, Professor Emeritus of Rhetoric and Linguistics with a courtesy appointment in Modern Languages – Ph.D., University of Michigan; Carnegie Mellon, 1997–.

CHRISTOPHER M. JONES, Teaching Professor of French & Francophone Studies and Director of Modern Language Resource Center – Ph.D., University of Massachusetts, Amherst; Carnegie Mellon, 1993–.

ELISABETH KASKE, Associate Professor of Chinese Studies – Ph.D., Heidelberg University; Carnegie Mellon, 2010–.

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GANG LIU, Assistant Teaching Professor of Chinese Studies – Ph.D., University of Michigan; Carnegie Mellon, 2010–.

BRIAN MACWHINNEY, Professor of Psychology with a courtesy appointment in Modern Languages – Ph.D., University of California, Berkeley; Carnegie Mellon, 1981–.

MAME NIANG-MEUNIER, Assistant Professor of French & Francophone Studies – Ph.D., Louisiana State University; Carnegie Mellon, 2012–.

SUSAN G. POLANSKY, Teaching Professor of Hispanic Studies and Head of Modern Languages – Ph.D., Boston College; Carnegie Mellon, 1986–.

GIOVANNI PUPPO, Instructor of Italian – Ph.D., University of Rome; Carnegie Mellon, 1975–.

MARIA DEL MAR ROSA-RODRIGUEZ, Assistant Professor of Hispanic Studies – Ph.D., Emory University; Carnegie Mellon, 2009–.

JURIS SILENIEKS, Professor Emeritus of French – Ph.D., University of Nebraska; Carnegie Mellon, 1960–.

CANDACE SKIBBA, Assistant Teaching Professor of Hispanic Studies – Ph.D., University of Wisconsin-Madison; Carnegie Mellon, 2006–.

DONALD SUTTON, Professor Emeritus of History with a courtesy appointment in Modern Languages – Ph.D., Cambridge University; Carnegie Mellon, 1969–.

NAOKO TAGUCHI, Associate Professor of Japanese and Second Language Acquisition – Ph.D., Northern Arizona University; Carnegie Mellon, 2005–.

THERESE TARDIO, Associate Teaching Professor of Hispanic Studies – Ph.D., University of Pittsburgh; Carnegie Mellon, 2001–.

G. RICHARD TUCKER, Paul Mellon University Professor Emeritus of Applied Linguistics with a courtesy appointment in Psychology – Ph.D., McGill University; Carnegie Mellon, 1992–.

JAN VAIRO, Senior Lecturer – M.A., University of Pittsburgh; Carnegie Mellon, 1992–.

REMI (ADAM) VAN COMPERNOLLE, Assistant Professor of French & Francophone Studies & Second Language Acquisition – Ph.D., Penn State; Carnegie Mellon, 2012–.

MICHAEL J. WEST, Teaching Professor of French & Francophone Studies – Ph.D., University of California-Santa Barbara; Carnegie Mellon, 1989–.

DANIELLE WETZEL, Teaching Professor and Director of First Year Writing with a courtesy appointment in Modern Languages – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2006–.

SETH WIENER, Assistant Professor of Second Language Acquisition and Chinese – Ph.D., Ohio State University; Carnegie Mellon, 2015–.

SUE-MEI WU, Teaching Professor of Chinese Studies – Ph.D., Ohio State University; Carnegie Mellon, 2000–.

TIANXUE YAO, Senior Lecturer – M.A., Carnegie Mellon University, M.A., JiLin University; Carnegie Mellon, 1996–.

YOSHIHIRO YASUHARA, Associate Teaching Professor of Japanese Studies – Ph.D., Pennsylvania State University; Carnegie Mellon, 2010–.

BONNIE L. YOUNGS, Teaching Professor of French & Francophone Studies and Director of Undergraduate Studies – Ph.D., University of Pennsylvania; Carnegie Mellon, 1993–.

YUEMING YU, Teaching Professor of Chinese Studies – Ed.D., University of Pittsburgh; Carnegie Mellon, 1992–.

Department of Philosophy

David Danks, Department Head
Office: Baker Hall 161
<http://www.hss.cmu.edu/philosophy/index.php>

The Department of Philosophy was founded in 1985 and reflects the tradition of philosophy as a central discipline in the humanities. The department has achieved an international reputation through the acclaimed research of its members and its innovative educational programs, not only in traditional topics such as ethics, philosophy of mind, logic, and theory of knowledge, but in such contemporary and applied areas as automated theorem proving, machine learning, the foundations of statistics, causal discovery, forward learning theory, game and decision theory, conflict resolution, and business ethics.

Philosophy thrives through contact with other disciplines. Interdisciplinary work, a traditional strength of the Carnegie Mellon community, is vital to the department and is reflected in the courses we offer, many of which incorporate substantive material from a range of other disciplines. Some courses are actually team-taught with professors from other departments and schools around the university.

Our programs are designed to develop our students' analytical sophistication and their practical and theoretical skills in specializations outside the department (see the sample curricula below). The department welcomes and, indeed, encourages minors and additional majors from other disciplines who are interested in reflecting on the foundation of their own subjects. The department offers two different undergraduate major programs, and jointly sponsors two interdepartmental majors: Ethics, History, and Public Policy (with the Department of History), and Linguistics (with English, Modern Languages, and Psychology):

- the B.A. or B.S. in Ethics, History, and Public Policy (interdisciplinary major with Department of History)
- the B.S. in Logic and Computation
- the B.A. in Philosophy
- the B.A. in Linguistics (interdisciplinary major with Departments of English, Modern Languages, and Psychology)

The major in Logic and Computation is perhaps the most non-traditional of the department's majors. It offers students a firm background in computer science, together with a solid grounding in logic, philosophy, and mathematics. This reflects the department's commitment to the use of formal, analytic methods in addressing philosophical issues. A flexible system of electives allows students to focus their efforts in any of a wide range of disciplines, from engineering to the fine arts. As a capstone to the program, students engage in original research in their senior year, and write a thesis under the direction of an advisor.

The department also sponsors four minor programs:

- the minor in Ethics
- the minor in Linguistics
- the minor in Logic and Computation
- the minor in Philosophy

Finally, the department offers two master's programs directly extending the departmental majors. Both programs are coordinated with and build on the undergraduate programs, so that majors can complete the requirements for the master's degree in one additional year:

- the M.S. in Logic and Computation
- the M.A. in Philosophy

Students who choose the appropriate specialized track in the Logic and Computation major (namely, sample 2 of the Curricula listed below) can be admitted to the M.S. program in Language and Information Technology offered by the School of Computer Science. To complete the discussion of departmental programs, it should be mentioned that the department sponsors as part of the Program in Pure and Applied Logic (offered jointly with the Departments of Computer Science and Mathematics) a Ph.D. in Logic, Computation, and Methodology.

The Major in Ethics, History, and Public Policy

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<http://www.cmu.edu/hss/ehpp/>

The B.A./B.S. in Ethics, History, and Public Policy is an interdepartmental major offered jointly by the Departments of History and Philosophy. It prepares students for leadership positions by providing them with a rigorous, interdisciplinary humanistic and social-scientific education. It also serves as an excellent springboard for graduate study in a wide variety of disciplines such as law, public policy, ethics, and advocacy. The program focuses equally on the historical understanding of how modern-day problems have evolved, and the importance of developing clear criteria for ethical decision-making. The capstone project course provides students with the opportunity to engage with real-world public policy challenges using the methods, theories, and knowledge that they have gained through the major. Offered jointly by the departments of History and Philosophy, the B.A./B.S. in EHPP encourages specialization, internship experiences, and research in a wide range of policy areas.

Curriculum

Students graduating with a primary major in Ethics, History, and Public Policy may elect to receive either a Bachelor of Arts or a Bachelor of Science Degree (additional requirements apply; see below). Basic requirements include 120 units encompassing 9 units in Economics, 36 units in History, 36 units in Philosophy, 27 units of elective courses, and a 12-unit senior capstone course. This program may also be taken as an additional (e.g., second) major.

I. Economics Requirement 9 units

Choose one of the following:

73-100	Principles of Economics	9
88-220	Policy Analysis I	9

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II. History Core 36 units

Choose one 9-unit course from each category below:

Policy History (9 units)

79-300	History of American Public Policy	9
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U.S. History (9 units)

79-240	The Development of American Culture	9
79-249	20th Century U.S. History	9

Non-U.S. History (9 units)

79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-223	Mexico: From the Aztec Empire to the Drug War	9
79-226	African History: Earliest Times to 1780	9
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-237	Comparative Slavery	9
79-251	India/America: Democracy, Diversity, Development	9
79-261	Chinese Culture and Society	9

79-262	Modern China	9
79-264	Tibet in History and Imagination	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-307	Religion and Politics in the Middle East	9

Historical Methods and Approaches (9 units)

79-200	Introduction to Historical Research	9
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III. Philosophy Core 36 units

Choose one 9-unit course from each category below. No more than 18 units at the 100 level may be counted toward this requirement.

Ethics (9 units)

80-130	Introduction to Ethics	9
80-230	Ethical Theory	9

Political Philosophy (9 units)

80-135	Introduction to Political Philosophy	9
80-235	Political Philosophy	9

Foundations of Social Science (9 units)

80-221	Philosophy of Social Science	9
80-321	Causation, Law, and Social Policy	9
80-324	Philosophy of Economics	9
80-337	Philosophy, Politics & Economics	9

Applied Philosophy (9 units)

80-136	Social Structure, Public Policy & Ethics	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
80-335	Deliberative Democracy: Theory and Practice	9
80-348	Health Development and Human Rights	9
80-447	Global Justice	9

IV. Senior Capstone Project Course 12 units

79-449	EHPP Project Course [cross-listed]	12
80-449	EHPP Project Course	12

The Ethics, History and Public Policy Project Course is required for the Ethics, History and Public Policy major and is taken in the fall semester of the senior year. In this capstone course, Ethics, History and Public Policy majors carry out a collaborative research project that examines a compelling current policy issue that can be illuminated with historical research and philosophical and policy analysis. The students develop an original research report based on both archival and contemporary policy analysis and they present their results to a client organization in the community.

V. Elective Courses 27 units

Choose any three courses from any category or categories shown below.

Engineering and Public Policy (some courses have prerequisites; see EPP catalog listing)

19-424	Energy and the Environment	9
19-426	Environmental Decision Making	9
19-448	Science, Technology & Ethics	9

Business

70-311	Organizational Behavior	9
70-321	Negotiation and Conflict Resolution	9
70-332	Business, Society and Ethics	9
70-364	Business Law	9
70-365	International Trade and International Law	9
70-430	International Management	9

Economics (some courses have prerequisites; see Economics catalog listing)

73-148	Environmental Economics	9
73-310	Evolution of Economic Ideas and Analysis	9
73-352	Public Economics	9

73-358	Economics of the Environment and Natural Resources	9
73-359	Benefit-Cost Analysis	9
73-365	Firms, Market Structures, and Strategy	9
73-372	International Money and Finance	9
73-375	History of Money and Monetary Policy	9
73-408	Law and Economics	9
73-476	American Economic History	9

English

76-492	Rhetoric of Public Policy	9
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History

Courses from the EHPP History Core (above) may be taken as electives only if they are not being used to fulfill the core requirement. Double counting is not permitted.

79-217	The War in Vietnam	9
79-221	Development and Democracy in Latin America	9
79-231	American Foreign Policy: 1945-Present	9
79-233	The United States and the Middle East since 1945	9
79-242	African American History: Reconstruction to the Present	9
79-253	American Massacres in History and Memory	6
79-267	The Soviet Union in World War II: Military, Political, and Social History	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-296	Perspectives on Social Protest	9
79-298	Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal	6
79-299	Trafficking Persons: Children in a Global Context	9
79-301	History of Surveillance: From the Plantation to Edward Snowden	6
79-302	Drone Warfare: Ethics, Law, Politics, History, and Strategy	6
79-303	Pittsburgh and the Transformation of Modern Urban America	6
79-305	Moneyball Nation: Data in American Life	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-312	International Human Rights Institutions in Theory and Practice	6
79-320	Women, Politics, and Protest	9
79-325	U.S. Gay and Lesbian History	6
79-331	Body Politics: Women and Health in America	9
79-338	History of Education in America	9
79-339	Juvenile Delinquency and Film (1920 to "The Wire")	9
79-340	Juvenile Delinquency and Juvenile Justice	9
79-342	Introduction to Science and Technology Studies	9
79-349	The Holocaust in Historical Perspective	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-359	Terrorism and U.S. National Security	6
79-371	African American Urban History	9
79-374	American Environmental History: Critical Issues	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
79-383	Epidemics, Disease, and Public Health	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
79-389	Stalin and Stalinism	9

Philosophy

Courses from the EHPP Philosophy Core (above) may be taken as electives only if they are not being used to fulfill the core requirement. Double counting is not permitted.

80-256	Modern Moral Philosophy	9
80-305	Rational Choice	9
80-405	Game Theory	9

84-310	International Political Economy and Organizations	9
84-380	Grand Strategy in the United States	9
84-393	Legislative Decision Making: U.S. Congress	9
84-402	Judicial Politics and Behavior	9

Social and Decision Sciences

88-223	Decision Analysis and Decision Support Systems	9
88-281	Topics in Law: 1st Amendment	9
88-343	Economics of Technological Change	9
88-345	Perspectives on Industrial Research and Development	9
88-347	Complex Technological Systems: Past, Present, and Future	9
88-371	Entrepreneurship, Regulation and Technological Change	9
88-387	Social Norms and Economics	9
88-423	Institutions, Entrepreneurship, and Innovation	9
88-444	Public Policy and Regulation	9

VI. Bachelor of Science Option

Students may elect to earn a Bachelor of Science rather than a Bachelor of Arts degree by completing two courses from the list below, or by petitioning the Director of EHPP to accept equivalent courses as substitutions.

21-257	Models and Methods for Optimization	9
36-202	Statistical Methods	9
or 36-208	Regression Analysis	
36-207	Probability and Statistics for Business Applications	9
36-303	Sampling, Survey and Society	9
36-309	Experimental Design for Behavioral and Social Sciences	9
80-305	Rational Choice	9
88-251	Empirical Research Methods	9

Additional Major

The B.A./B.S. in Ethics, History, and Public Policy may be scheduled as an additional major in consultation with the Director of Ethics, History, and Public Policy, Professor Alex John London, ajlondon@andrew.cmu.edu.

Ethics, History, and Public Policy Sample Curriculum

Junior Year		Senior Year	
Fall	Spring	Fall	Spring
Core requirement in Economics	Core requirement in History or Philosophy	Capstone Course	EHPP Elective Course
Core requirement in History or Philosophy	Core requirement in History or Philosophy	EHPP Elective Course	Second Course (open)
Core requirement in History or Philosophy	Core requirement in History or Philosophy	EHPP Elective Course	Third Course (open)
Core requirement in History or Philosophy	Core requirement in History or Philosophy	Fourth Course (open)	Fourth Course (open)
Core requirement in History or Philosophy	Fifth Course (open)	Fifth Course (open)	Fifth Course (open)

The above sample program is presented as a two-year (junior-senior year) plan for completing EHPP major requirements. Its purpose is to show that this program can be completed in as few as two years; not that it must be. Students may enter the EHPP major, and begin major course requirements, as early as the start of the sophomore year, or even in the first year. Students should consult their advisor when planning their program.

The Major in Linguistics

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Linguistics is the study of human language, and it encompasses a broad spectrum of research questions, approaches and methodologies. Some linguists are concerned with the cognitive aspects of language learning, production and comprehension; some are concerned with language as a social and cultural phenomenon; others engage in the analysis of linguistic form and meaning, some from a functional and others from a formal perspective. There are also computational approaches to linguistics with both applied and theoretical goals.

The major in Linguistics reflects the multidisciplinary character of the field and of the Linguistics faculty here at Carnegie Mellon, offering a program which provides students with the fundamental tools of linguistic analysis while maintaining a focus on the human context in which language is learned and used. The major is available as either a primary major or an additional major. It is an ideal choice for students with a general interest in their own or other languages, and combines well thematically with studies in any of the departments represented in the major.

Curriculum

The Linguistics major requires a total of 12 courses, which includes 2 semesters of language study. In addition, primary majors in Linguistics are required to write a Senior Thesis in their final year. At least three courses (not including specific language courses) must be at the 300-level or higher. All courses counted towards the major must be taken for a letter grade and passed with a grade of "C" or above. For Dietrich College students, up to 2 of these courses may be counted also as satisfying the college's general education requirements (as long as the double-counting maximum established by the college is not exceeded), with permission of the major director. Students from other colleges may fulfill their Humanities requirements using courses taken towards the Linguistics Major. However, no courses may be counted simultaneously towards the Linguistics Major and any other major.

Introductory course

80-180	Nature of Language	9
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Fundamental Skills

Take **one** course from **each** of the following core subject areas:

Sounds

80-282	Phonetics and Phonology I	9
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Structure

76-389	Rhetorical Grammar	9
80-280	Linguistic Analysis	9
80-285	Natural Language Syntax	9

Meaning

80-381	Meaning in Language	9
80-383	Language in Use	9
76-385	Introduction to Discourse Analysis	9

Breadth

Take **one** course from **each** of the following breadth subject areas:

Area 1: Language Learning and Language Cognition

76-420	Process of Reading and Writing	9
82-280	Learning About Language Learning	9
82-383	Second Language Acquisition: Theories and Research	9
82-585	Topics in Second Language Acquisition	9
85-354	Infant Language Development	9
85-421	Language and Thought	9

Area 2: Discourse, Society and Culture

76-318	Communicating in the Global Marketplace	9
76-385	Introduction to Discourse Analysis	9
76-386	Language & Culture	9
82-273	Introduction to Japanese Language and Culture	9
82-305	French in its Social Contexts	9
82-311	Arabic Language and Culture I	9

82-312	Arabic Language and Culture II	9
82-333	Introduction to Chinese Language and Culture	Var.

Electives

Take **four** additional electives. These can be **additional courses from the Fundamental Skills courses or Breadth courses listed above, or any other course which is approved** by the Director as a linguistics elective. Listed below are the additional electives taught on a regular basis. **Additional appropriate courses** are offered irregularly or on a one-off basis. The Director will provide students with a list of possible electives each semester, and will assist students in selecting electives which are consistent with their goals and interests.

76-373	Argument	9
76-378	Literacy: Educational Theory and Community Practice	9
76-451	Topics in Language Study	9
76-476	Rhetoric of Science	9
80-281	Language and Thought	9
80-283	Syntax and Discourse	9
80-284	Invented Languages	9
80-286	Words and Word Formation: Introduction to Morphology	9
80-287	Historical and Comparative Linguistics	9
80-380	Philosophy of Language	9
80-382	Phonetics and Phonology II	9
80-384	Linguistics of Turkic Languages	9
80-385	Linguistics of Germanic Languages	9
82-373	Structure of the Japanese Language	9
82-388	Understanding Second Language Fluency	9
82-442	Analysis of Spoken Spanish	9
82-444	The Structure of Spanish	9
82-476	Japanese Discourse Analysis	9
82-480	Social and Cognitive Aspects of Bilingualism	9
11-411	Natural Language Processing	12
11-716	Graduate Seminar on Dialog Processing	6
11-721	Grammars and Lexicons	12
11-722	Grammar Formalisms	12
11-761	Language and Statistics	12
11-762	Language and Statistics II	12
15-492	Special Topic: Speech Processing	12

Language Requirement

Students must successfully complete two semesters of consecutive language courses. (Note that students may not 'test out' of this requirement. However, language courses taken at other institutions or as part of a study abroad program will typically substitute for a semester of language study.)

Senior Thesis [primary majors only]

Primary majors must complete a senior thesis (a workload equivalent to a 12-unit course) during their senior year. Topics must be approved by an advisor, who will work with the student and guide the thesis project.

Notes

- Course numbers 82-305, 82-311, 32-312, 82-373, 82-442, 82-444, 82-476 are taught in the language of analysis.
- All 11-xxx and 15-xxx courses have significant Computer Science prerequisites. Interested students should check with the course instructor before registering.
- Language specific "Language and Culture" courses may be taken either as electives or towards the second breadth area. However only one such course per language area may be counted towards the major.

The Major in Logic and Computation

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The Logic and Computation curriculum takes advantage of the preparation provided by the H&SS General Education Program in mathematics,

philosophy, psychology, and statistics. It is flexible in that it permits students to focus on any of a number of areas including (but not limited to):

- computer science;
- language and information technology;
- artificial intelligence and cognitive science;
- logic and the foundations of mathematics;
- methodology and philosophy of science.

Students in the program take a common core of courses in logic, methodology, and computer science, together with an associated seminar in their senior year. The individual focus is achieved by selecting a sequence of four advanced and closely related courses. It is in this area of focus (or specialization) that students write their senior thesis under the supervision of a faculty member. A number of sample curricula are presented below.

The resulting education in logic, analytic philosophy, mathematics, statistics, and computer science enables students to pursue professional careers or graduate study. The analytic and communication skills developed in the major support a wide range of career choices, including those among the fields of technology, business, and law. Fields of graduate study for which students are well prepared include, for example, computer science, cognitive science, philosophy, logic, and linguistics.

Students who are interested in pursuing this major, or who are pursuing it already, should take note of the Cognitive Science major in the Department of Psychology. That major is so closely related that it is not difficult to pursue it as an additional major, and it provides an intellectually exciting complement.

Curriculum

Logic and Computation is a B.S. degree. In their freshman and sophomore years, students are expected to take three courses that provide preparation in computer science, mathematics, and statistics: 15-112 Fundamentals of Programming and Computer Science, 21-127 Concepts of Mathematics, 36-201 Statistical Reasoning and Practice. 80-211 Logic and Mathematical Inquiry is part of the major's Core Requirements, but should be taken no later than the spring of the sophomore year. This also applies to the computer science sequence 15-122 and 15-150.

NOTE: Students should complete the prerequisites before their junior year. It is strongly recommended that students take 80-211 Logic and Mathematical Inquiry no later than the spring of their sophomore year and, if possible, also 15-122 and 15-150/15-211. However, with suitable planning and advice from the program director, it is possible to complete the program in two years, beginning in the junior year.

The course requirements for the major consist of seven core courses (including one seminar) and four electives. The core courses provide comprehensive background in logic, computability, and analytic philosophy. 80-310 Formal Logic and 80-150 Nature of Reason must be taken no later than the fall of the junior year. Four advanced electives are chosen in the area of focus, and should support independent research towards fulfilling the senior thesis requirement. In their senior year, students present and discuss their research in 80-511 Thesis Seminar. All courses, if taken at CMU, must be taken for a letter grade and passed with a grade of "C" or above.

2

Prerequisites	29 units
15-110 Principles of Computing	10
21-127 Concepts of Mathematics	10
36-201 Statistical Reasoning and Practice	9

Logic and Computation Core	69-71 units
80-150 Nature of Reason	9
80-211 Logic and Mathematical Inquiry	9
80-310 Formal Logic	9
80-311 Undecidability and Incompleteness	9
15-122 Principles of Imperative Computation	10
15-150 Principles of Functional Programming	10
or 15-211 Fundamental Data Structures and Algorithms	
80-511 Thesis Seminar	9

Logic and Computation Electives 36 units

Bearing in mind prerequisites, Logic and Computation majors must complete four advanced courses in areas that use logical and computational

tools, such as philosophy, computer science, linguistics, mathematical logic, psychology, or statistics. The sequence of courses, mostly at the 300-level, must be selected in consultation with the program director.

Sample Curricula

Here are five samples of Logic and Computation curricula (beyond the core courses), each reflecting a different emphasis.

Sample 1.

A student interested in Computer Science might take the following courses:

80-315	Modal Logic	9
80-413	Category Theory	9
15-312	Foundations of Programming Languages	12
15-317	Constructive Logic	9

Sample 2.

A student interested in Language and Information Technology might take the following courses:

80-280	Linguistic Analysis	9
80-281	Language and Thought	9
80-381	Meaning in Language	9
80-383	Language in Use	9
80-580	Seminar on the Philosophy of Language	9

Sample 3.

A student interested in Artificial Intelligence and Cognitive Science might take the following courses:

80-314	Logic and Artificial Intelligence	9
80-315	Modal Logic	9
80-411	Proof Theory	9
85-412	Cognitive Modeling	9

Sample 4.

A student interested in Logic and the Foundations of Mathematics might consider the following courses:

80-254	Analytic Philosophy	9
80-312	Philosophy of Mathematics	9
80-365	Ramsey	9
80-411	Proof Theory	9
80-413	Category Theory	9

Sample 5.

A student interested in Methodology might consider the following courses:

80-220	Philosophy of Science	9
80-221	Philosophy of Social Science	9
80-321	Causation, Law, and Social Policy	9
36-309	Experimental Design for Behavioral and Social Sciences	9

Logic and Computation Degree Requirements (minimum) 360 units

Logic and Computation as a Second Major

The Logic and Computation major is also suitable as a second major for students in H&SS or for students in other colleges within the university. Non-H&SS students interested in an additional major in Logic and Computation need to take only those courses in the H&SS General Education Program that are prerequisites to courses required in the major; all other H&SS General Education requirements are waived for these students. Depending on the student's back-ground, the requirements of the second major in Logic and Computation can be fulfilled with as few as five additional courses. However, the department limits the courses that may be 'double counted'; the core courses in the Philosophy department may not be double counted.

The M.S. Program in Logic and Computation

The Department of Philosophy also offers a graduate M.S. degree in Logic and Computation, which culminates with the writing of a master's thesis. It is ordinarily a two-year program, but students in the Logic and Computation major are able to complete the additional requirements in one year. Interested students are invited to contact the department for further information and apply to the program in their senior year. Details can be found on the department's homepage: <http://hss.cmu.edu/philosophy/>

The Major in Philosophy

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The Major in Philosophy is intended to be flexible and to facilitate double majors in other fields (including majors with a strong professional focus). It provides students with a broad humanities education and sharpens their analytical skills. We encourage, but do not require, students to choose a thematic concentration through their electives. Sample curricula emphasizing Pre-Law, Metaphysics and Epistemology, Ethics and Social Philosophy, and Philosophy of Mind are suggested below. However, alternative emphases can be proposed and approved by the Director. The Major in Philosophy is a B.A. degree.

Curriculum

In addition to the general education requirements for the student's college, Philosophy primary majors and additional majors must complete 80-100 Introduction to Philosophy and nine Philosophy courses in the Areas listed below. The 80-100 requirement must be fulfilled before the first semester of the junior year. Only two of the remaining nine courses may be at the 100-level, and two of the nine courses must be at the 300-level or higher. All ten courses, if taken at CMU, must be taken for a letter grade and passed with a grade of "C" or above. Courses from other universities, as well as an 80-100 skills test, may be substituted with permission of the Director. For H&SS students, up to 4 of these courses may be counted also as satisfying the College's General Education requirements, with permission of the Director. Students are to choose one course out of each of the Areas 1-4, two courses out of Area 5, and may freely select three courses in Area 6. As per the requirement of the College of H&SS, a student's Freshman Seminar course may not count toward the fulfillment of the major requirements.

Introduction to Philosophy 9 units

80-100	Introduction to Philosophy	9
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Area 1: Values and Normative Theory 9 units

One of the following:

80-130	Introduction to Ethics	9
80-135	Introduction to Political Philosophy	9
80-136	Social Structure, Public Policy & Ethics	9
80-230	Ethical Theory	9
80-235	Political Philosophy	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
80-248	Engineering Ethics	9
80-335	Deliberative Democracy: Theory and Practice	9
80-337	Philosophy, Politics & Economics	9
80-348	Health Development and Human Rights	9
80-430	Ethics and Medical Research	9
80-431	Meta-ethics	9
80-447	Global Justice	9
80-530	Seminar on Ethical Theory	Var.

Area 2: Philosophy of Mind/Language/Metaphysics 9 units

One of the following:

80-180	Nature of Language	9
80-270	Philosophy of Mind	9
80-271	Philosophy and Psychology	9
80-275	Metaphysics	9
80-276	Philosophy of Religion	9
80-280	Linguistic Analysis	9
80-281	Language and Thought	9
80-282	Phonetics and Phonology I	9
80-283	Syntax and Discourse	9
80-380	Philosophy of Language	9
80-381	Meaning in Language	9
80-382	Phonetics and Phonology II	9
80-383	Language in Use	9
80-384	Linguistics of Turkic Languages	9

80-575	Seminar on Metaphysics	Var.
80-580	Seminar on the Philosophy of Language	9

Area 3: Logic/Philosophy of Mathematics9 units

One of the following:

80-110	Nature of Mathematical Reasoning	9
80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-212	Arguments and Logical Analysis	9
80-310	Formal Logic	9
80-311	Undecidability and Incompleteness	9
80-312	Philosophy of Mathematics	9
80-314	Logic and Artificial Intelligence	9
80-315	Modal Logic	9
80-411	Proof Theory	9
80-413	Category Theory	9
80-513	Seminar on Philosophy of Mathematics	9
80-514	Categorical Logic Seminar	9

Area 4: Epistemology/Metaphysics9 units

One of the following:

80-150	Nature of Reason	9
80-201	Epistemology	9
80-208	Critical Thinking	9
80-220	Philosophy of Science	9
80-221	Philosophy of Social Science	9
80-222	Measurement and Methodology	9
80-226	Revolutions in Science	9
80-305	Rational Choice	9
80-321	Causation, Law, and Social Policy	9
80-322	Philosophy of Physics	9
80-323	Philosophy of Biology	9
80-324	Philosophy of Economics	9
80-405	Game Theory	9
80-515	Seminar on the Foundations of Statistics	9
80-516	Seminar on Causation	Var.
80-520	Seminar on Philosophy Science	9
80-521	Seminar on Formal Epistemology	9

Area 5: History of Philosophy18 units

Two of the following:

80-150	Nature of Reason	9
80-226	Revolutions in Science	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-252	Kant	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-256	Modern Moral Philosophy	9
80-257	Nietzsche	9
80-258	Hume	9
80-261	Empiricism and Rationalism	9
80-262	Introduction to the Philosophy of Bertrand Russell	9
80-264	William James and Philosophical Psychology	9
80-363	19th Century Foundations of Science	9

Area 6: Elective27 units

Three other philosophy courses, or appropriate courses from other departments, with the permission of the Director.

Sample Curricula

Here are four sample curricula, reflecting different emphases.

1. For an emphasis on Law & Social Policy, a student might take:

Area 1	
80-235	Political Philosophy 9

Area 2	
80-180	Nature of Language 9
Area 3	
80-211	Logic and Mathematical Inquiry 9
Area 4	
80-208	Critical Thinking 9
Area 5	
80-150	Nature of Reason 9
80-250	Ancient Philosophy 9
Area 6	
80-321	Causation, Law, and Social Policy 9
80-348	Health Development and Human Rights 9
80-447	Global Justice 9

2. For an emphasis on Philosophy of Science, a student might take:

Area 1	
80-136	Social Structure, Public Policy & Ethics 9
Area 2	
80-275	Metaphysics 9
Area 3	
80-211	Logic and Mathematical Inquiry 9
Area 4	
80-220	Philosophy of Science 9
or 80-221	Philosophy of Social Science 9
Area 5	
80-250	Ancient Philosophy 9
80-226	Revolutions in Science 9
Area 6	
80-150	Nature of Reason 9
80-221	Philosophy of Social Science 9
80-322	Philosophy of Physics 9
80-323	Philosophy of Biology 9

3. For an emphasis on Ethics and Social Philosophy, a student might take:

Area 1	
80-230	Ethical Theory 9
Area 2	
80-276	Philosophy of Religion 9
Area 3	
80-110	Nature of Mathematical Reasoning 9
Area 4	
80-221	Philosophy of Social Science 9
or 80-321	Causation, Law, and Social Policy 9
Area 5	
80-250	Ancient Philosophy 9
Area 6	
80-321	Causation, Law, and Social Policy 9

4. For an emphasis on Philosophy of Mind, a student might take:

Area 1	
80-130	Introduction to Ethics 9
Area 2	
80-270	Philosophy of Mind 9
Area 3	
80-211	Logic and Mathematical Inquiry 9
Area 4	
80-201	Epistemology 9
Area 5	
80-251	Modern Philosophy 9
Area 6	
80-275	Metaphysics 9
80-257	Nietzsche 9
80-314	Logic and Artificial Intelligence 9

Additional Major

Students who want an additional major in Philosophy must fulfill the same departmental requirements as primary majors in Philosophy.

The M.A. Program in Philosophy

The Department of Philosophy also offers a graduate M.A. degree in Philosophy, which culminates with the writing of a master's thesis. It is ordinarily a two-year program, but students in the Philosophy major are able to complete the additional requirements in one year. Interested students are invited to visit the department's homepage for further information: www.hss.cmu.edu/philosophy/.

Philosophy Department Minors

All majors in the Department allow for minors; in addition, there is a Minor in Ethics and an interdepartmental minor in Linguistics. The requirements are again designed to be flexible and to allow students to tailor courses to their special interests, while providing some breadth.

The Minor in Ethics

With the explosive growth of science and technology have come both new possibilities and new problems. Developments in medicine, in biology, in chemistry, in nuclear engineering or in computer science all have costs as well as benefits, and they present us with many hard choices. Some of the hardest of these new problems are moral problems.

The Philosophy Department's Minor in Ethics introduces students to central ethical concepts and theories proposed and defended by the great philosophers of the past; it provides an understanding of how these theories and concepts can be applied to practical problems. This background in ethical theory and its applications should help students to respond more sensitively and appropriately to the new and unavoidable ethical problems that businesses, unions, and branches of government must face.

Ethics Core Courses 27 units

Complete three courses from any of the following areas with at least two courses at the 200-level or higher.

80-130	Introduction to Ethics	9
80-135	Introduction to Political Philosophy	9
80-136	Social Structure, Public Policy & Ethics	9
80-230	Ethical Theory	9
80-235	Political Philosophy	9
80-241	Ethical Judgments in Professional Life	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
80-335	Deliberative Democracy: Theory and Practice	9
80-337	Philosophy, Politics & Economics	9
80-348	Health Development and Human Rights	9
80-430	Ethics and Medical Research	9
80-447	Global Justice	9

Ethics Electives 18 units

Complete two courses at the 200-level or higher.

The Minor in Linguistics

The Interdepartmental Minor in Linguistics is jointly sponsored with the departments of English, Modern Languages, and Psychology. It synthesizes the linguistics related offerings in these departments and provides students with an academic experience that reflects both the interdisciplinary character of the subject and its cross-departmental representation in H&SS. Students who wish to receive a minor in Linguistics must complete six courses. For a detailed discussion of the curriculum and the flexible electives, consult the Dietrich College Interdisciplinary Minors section of the catalog.

The Minor in Logic and Computation

The Minor in Logic and Computation provides students with general course work in logic, the theory of computation, and philosophy. Students must complete six courses, among them the following three core courses.

Logic and Computation Core Courses 27 units

80-150	Nature of Reason	9
80-211	Logic and Mathematical Inquiry	9

or 80-210	Logic and Proofs	
80-310	Formal Logic	9
or 80-311	Undecidability and Incompleteness	

Logic and Computation Electives 27 units

Students must take two courses in the Philosophy Department at the 300-level or higher, in subjects related to logic and computation, and an additional course at the 300-level or higher in an area that uses logical and computational tools, such as philosophy, computer science, linguistics, mathematics, psychology, or statistics. The choice of electives must be approved by the program director.

The Minor in Philosophy

The Minor in Philosophy allows students to complement their primary majors with a broad philosophical grounding.

Logic/Methodology Requirements 9 units

Complete one course:

80-110	Nature of Mathematical Reasoning	9
80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-212	Arguments and Logical Analysis	9
80-220	Philosophy of Science	9
80-221	Philosophy of Social Science	9
80-222	Measurement and Methodology	9
80-226	Revolutions in Science	9
80-310	Formal Logic	9
80-311	Undecidability and Incompleteness	9
80-312	Philosophy of Mathematics	9
80-314	Logic and Artificial Intelligence	9
80-315	Modal Logic	9
80-321	Causation, Law, and Social Policy	9
80-322	Philosophy of Physics	9
80-323	Philosophy of Biology	9
80-324	Philosophy of Economics	9
80-411	Proof Theory	9
80-413	Category Theory	9
80-513	Seminar on Philosophy of Mathematics	9
80-514	Categorical Logic Seminar	9
80-515	Seminar on the Foundations of Statistics	9
80-516	Seminar on Causation	Var.
80-520	Seminar on Philosophy Science	9
80-521	Seminar on Formal Epistemology	9

History of Philosophy Requirements 18 units

Complete two courses:

80-150	Nature of Reason	9
80-226	Revolutions in Science	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-252	Kant	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-256	Modern Moral Philosophy	9
80-257	Nietzsche	9
80-258	Hume	9
80-261	Empiricism and Rationalism	9
80-262	Introduction to the Philosophy of Bertrand Russell	9
80-363	19th Century Foundations of Science	9
80-264	William James and Philosophical Psychology	9

Philosophy Electives 18 units

Complete 18.0 units in the Philosophy Department at the 200-level or higher.

The Honors Program

The H&SS Senior Honors Program provides recognition of outstanding performance by students majoring in Philosophy, Logic and Computation or Ethics, History, and Public Policy. Students have the opportunity to develop their skills and to apply their knowledge through completion of an honors thesis in their senior year. By completing the thesis, students earn 18 units of credit and qualify for graduation with College Honors. To qualify for the honors program, students must maintain a quality point average of at least 3.50 in the major and 3.25 overall, and be invited by the department to become a participant.

Undergraduate Research Fellows

Qualified upper level undergraduates, preferably majors in one of the Philosophy Department's programs, may apply to serve in their junior or senior years as fellows in the Laboratory for Symbolic and Educational Computing (LSEC). Applications are reviewed in the fall. Visit LSEC from the Department's website, <http://www.hss.cmu.edu/philosophy/labs-lsec.php>, or contact Professors Joseph Ramsey or Wilfried Seig for additional information.

Faculty

JEREMY AVIGAD, Professor of Philosophy – Ph.D., University of California, Berkeley; Carnegie Mellon, 1996–.

STEVEN AWODEY, Professor of Philosophy – Ph.D., University of Chicago; Carnegie Mellon, 1997–.

ADAM BJORNDAHL, Assistant Professor of Philosophy – Ph.D., Cornell University; Carnegie Mellon, 2014–.

ROBERT CAVALIER, Teaching Professor of Philosophy – Ph.D., Duquesne University; Carnegie Mellon, 1987–.

DAVID DANKS, Professor of Philosophy – Ph.D., University of California, San Diego; Carnegie Mellon, 2003–.

BENJAMIN R. GEORGE, Assistant Professor of Philosophy – Ph.D., University of California, Los Angeles; Carnegie Mellon, 2014–.

CLARK GLYMOUR, Alumni University Professor of Philosophy – Ph.D., Indiana University; Carnegie Mellon, 1984–.

MARALEE HARRELL, Associate Teaching Professor of Philosophy – Ph.D., University of California, San Diego; Carnegie Mellon, 2003–.

KEVIN T. KELLY, Professor of Philosophy – Ph.D., University of Pittsburgh; Carnegie Mellon, 1985–.

ALEX LONDON, Professor of Philosophy – Ph.D., University of Virginia; Carnegie Mellon, 2000–.

RICHARD SCHEINES, Professor of Philosophy – Ph.D., University of Pittsburgh; Carnegie Mellon, 1987–.

TEDDY I. SEIDENFELD, Herbert A. Simon Professor of Philosophy and Statistics – Ph.D., Columbia University; Carnegie Mellon, 1985–.

WILFRIED SIEG, Patrick Suppes Professor of Philosophy – Ph.D., Stanford University; Carnegie Mellon, 1985–.

MANDY SIMONS, Associate Professor of Philosophy – Ph.D., Cornell University; Carnegie Mellon, 1998–.

JOEL SMITH, Distinguished Career Teaching Professor of Philosophy – Ph.D., University of Pittsburgh; Carnegie Mellon, 2000–.

PETER L. SPIRITES, Professor of Philosophy – Ph.D., University of Pittsburgh; Carnegie Mellon, 1987–.

DANIELLE WENNER, Assistant Professor of Philosophy – Ph.D., Rice University; Carnegie Mellon, 2013–.

THOMAS WERNER, Assistant Teaching Professor of Philosophy – Ph.D., Rutgers University; Carnegie Mellon, 2003–.

KUN ZHANG, Assistant Professor of Philosophy – Ph.D., The Chinese University of Hong Kong; Carnegie Mellon, 2015–.

KEVIN ZOLLMAN, Associate Professor of Philosophy – Ph.D., University of California, Irvine; Carnegie Mellon, 2009–.

Special Faculty

CHRISTINA BJORNDAHL, Teaching Instructor – Ph.D. Candidate, Cornell University; Carnegie Mellon, 2014–.

DAVID GRAY, Assistant Teaching Professor of Philosophy, Carnegie Mellon-Qatar – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2009–.

DERRICK GRAY, Teaching Instructor – Ph.D., Rice University; Carnegie Mellon, 2013–.

ANDY NORMAN, Teaching Instructor – Ph.D., Northwestern University; Carnegie Mellon, 2006–.

JOSEPH RAMSEY, Director of Research Computing – Ph.D., University of California, San Diego; Carnegie Mellon, 2006–.

Affiliated Faculty

WAYNE WU, Associate Professor and Associate Director of CNBC – Ph.D., University of California, Berkeley; Carnegie Mellon, 2010–.

Emeritus Faculty

DANA S. SCOTT, Hillman University Professor of Mathematical Logic, Computer Science and Philosophy (Emeritus) – Ph.D., Princeton University; Carnegie Mellon, 1981–.

Institute for Politics and Strategy

Kiron K. Skinner, Director
Department Office: Porter Hall 223E

The Institute for Politics and Strategy (IPS) is dedicated to the study of politics through the discipline of political science with support from other social science disciplines. In this way, IPS carries on a respected tradition of interdisciplinary political science at Carnegie Mellon University. The Institute for Politics and Strategy also builds upon the university's rich heritage of applying basic science to issues of public policy.

At various times during the past fifty years, CMU faculty members have been innovators of what is now known as formal theory and public choice. Indeed, some of them were involved in the founding and early meetings of scholarly organizations in these areas. Political science teaching and research took place in numerous CMU colleges but by the early 2000s most teaching and research in political science occurred in the Department of Social and Decision Sciences (SDS). Home also to research and teaching in behavioral economics, complex social systems, decision science, and strategy, entrepreneurship, and technological change, SDS supported a rigorous undergraduate and doctoral program in political science focused on US politics, quantitative methods, formal theory, game theory, and social choice.

Started during the 1999-2000 academic year, the additional major in international relations stood alongside the political science major. That major, the university's first full-scale undergraduate teaching program in international relations, was a joint initiative by the Department of History, the Department of Modern Languages, and the Department of Social and Decision Sciences. As student enrollment flourished and the opportunity arose to develop the major's social science component, the additional major became a stand-alone course of study. It was renamed International Relations and Politics (IRP) and moved to the Department of Social and Decision Sciences. The name of the major signifies that those studying IRP will learn about international relations and domestic politics from the standpoint of the discipline of political science.

At the same time, IRP taps into and contributes to CMU's strengths in other social sciences such as decision science. Decidedly analytical and quantitative, the IRP major preserves and expands CMU's tradition in political science.

With the beginning of the 2015-16 academic year, IRP will be the flagship academic program in IPS. The major will continue to provide the rich set of courses and programmatic offerings that have made it an attractive course of study for students from all of CMU's colleges.

Basic science is the foundation for the public policy activities of IPS. Analytical social science and interdisciplinary research and teaching are used to better understand, explain, anticipate, and solve public policy problems.

The CMU traditions of analytical political science and applied social science are reflected in the range of degree programs and entities that IPS supports and oversees. The academic programs included in the Institute for Politics and Strategy are:

- International Relations and Politics Major (primary and additional);
- International Relations and Politics Minor;
- Politics and Public Policy Minor; and
- Master of Information Technology Strategy.

The IRP minor shares core courses with the IRP major. The minor in Politics and Public Policy has a greater focus on domestic politics and public policy than either the IRP major or minor. The Master of Information Technology Strategy (MITS) (<http://www.cmu.edu/mits>) program provides graduate students with core interdisciplinary competencies in cyber security. The master's program is a joint initiative by the College of Engineering, Dietrich College, and the School of Computer Science. IPS manages the Dietrich College portion of MITS. The Institute for Software Research, a department in the School of Computer Science, is the administrative home for MITS.

IPS administers these initiatives:

- The Center for International Relations and Politics;
- The Carnegie Mellon University Washington Semester Program; and
- The Institute for Strategic Analysis.

The Center for International Relations and Politics (CIRP) is a university hub for scholarly and policy-oriented activities on domestic and international issues. CIRP (<http://www.cmu.edu/ir>) supports and promotes student and

faculty research and hosts national and international thought leaders through its Policy Forum.

The Carnegie Mellon University Washington Semester Program (CMU/WSP) is a semester-long program for undergraduates interested in taking courses and interning in Washington. The minor in Politics and Public Policy may be earned by completing CMU/WSP and taking an additional core course in the International Relations and Politics major.

Founded in 2013, the Institute for Strategic Analysis facilitates and supports CMU faculty members interested in bringing their scientific research to bear upon problems of national security. These problems include terrorism, cyber challenges, war avoidance, intelligence, and the intersection of energy and security. ISA facilitates strategic engagements between CMU faculty and leaders in the defense and intelligence community as they seek mutually beneficial ways to have basic research inform national security policy.

The Major in International Relations and Politics

Kiron K. Skinner, Faculty Director; kskinner@andrew.cmu.edu, Porter Hall 223E
Emily Half, Academic Program Manager; ehalf@andrew.cmu.edu, Baker Hall A60C, 412-268-7082

The International Relations and Politics (IRP) major analyzes the role of politics at the national, regional, international, and transnational levels; examines political and institutional arrangements within and among these levels; and investigates the grand strategy of nation-states.

Statesmen, scholars, and policy makers often define grand strategy as the combination of diplomatic, economic, military, and political factors used by leaders to defend their respective nation-states. The IRP major investigates the way in which leaders and citizens construct grand strategy and national security policy more generally; the impact of domestic and international forces on states' security and economic policies; and the significance of alliances, coalitions, and international institutions for world politics.

Although the study of grand strategy and political institutions is the flagship initiative of the major, students are also able to study the effects of culture, economics, and society on the international system through a rich set of elective courses.

Thinking systematically about international and domestic politics is the core objective of the IRP major. To this end, the major has prerequisites in analytical methods, mathematics, and statistics that help to sharpen students' ability to undertake scientific analysis in the required substantive and historical courses. The major is rooted in the discipline of political science but also utilizes the interdisciplinary strengths of behavioral decision science, complex social systems, economics, strategy, entrepreneurship and technological change, and political history. Thus, students pursuing this major will use the analytic tools of game theory, economic and statistical analysis, qualitative analysis, rational choice theory, and theories of behavioral decision making as they study alliances, coalitions, institutions, and political strategy.

Recognizing the influence of language and culture on politics, students are required to complete the intermediate (200) level, or its equivalent, in a modern language other than English. Advanced-level study is strongly encouraged.

Open to all Carnegie Mellon undergraduates, the Carnegie Mellon University Washington Semester Program (CMU/WSP) allows students to study public policy and intern in Washington for one semester. Courses taken through CMU/WSP will count toward the elective sequence in public policy for IRP majors.

Students' understanding of politics is further informed by courses and colloquia offered by CMU's top-ranked departments, divisions, and schools in business, computer science, engineering, and the humanities.

IRP majors interested in developing their research skills are encouraged to apply for a research position with the Center for International Relations and Politics. They are also encouraged to join student organizations focused on domestic or international politics. Becoming involved in the Institute for Politics and Strategy, as well as attending lectures and events sponsored by the Center for International Relations and Politics will provide additional opportunities for students.

The International Relations and Politics major is offered through the Institute for Politics and Strategy. It is available as a primary major and additional major in the Dietrich College of Humanities and Social Sciences. Minors in International Relations and Politics and Politics and Public Policy are also available.

Prerequisites

All International Relations and Politics majors must complete mathematics, statistics, and analytic methods prerequisites (see below) by the end of the sophomore year.

Mathematics Prerequisite	Units
21-111-21-112 Calculus I-II or 21-120 Differential and Integral Calculus	10-20

Students who successfully pass the proctored Calculus Assessment on campus at the 21-120 level will be required to take a more advanced 21-xxx course for this prerequisite. 21-122, 21-240, or 21-256 are suggested.

Statistics Prerequisite	Units
36-201 Statistical Reasoning and Practice	9

Students must take one course (9-10 units) from the following set (or an approved alternative) of Analytic Methods courses. Students may not double count a course used to fulfill the Mathematics Prerequisite for the Analytic Methods Prerequisite.

Analytic Methods Prerequisite	Units
21-122 Integration and Approximation	10
21-256 Multivariate Analysis	9
36-303 Sampling, Survey and Society	9
36-315 Statistical Graphics and Visualization	9
80-210 Logic and Proofs	9
73-230 Intermediate Microeconomics	9
73-240 Intermediate Macroeconomics	9
80-305 Rational Choice	9
80-405 Game Theory	9
88-252 Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9
88-316 Game Theory	9
88-402 Modeling Complex Social Systems	9
88-424 Decision Theory and Rational Choice	9
88-435 Decision Science and Policy	9

Curriculum

Core Courses	Units
84-104 Decision Processes in American Political Institutions	9
84-265 Political Science Research Methods	9
84-275 Comparative Politics	9
84-326 Theories of International Relations	9
84-450 IRP Capstone Policy Forum	Var.
36-202 Statistical Methods	9
73-100 Principles of Economics or 88-220 Policy Analysis I	9

Language Requirement

Students are required to complete the intermediate (200) level or the equivalent in a modern language other than English. Advanced level study is strongly encouraged. Students who successfully pass a language placement exam on campus, at the intermediate II level or higher, are required to take an advanced language course to satisfy the language requirement.

45 units Electives

International Relations and Politics students will either:

Option 1) take 45 units (five courses) from the elective lists below. Students must take three courses (27 units) from the Grand Strategy and Political Institutions category. The remaining two courses (18 units) must come from the Economics and Society and/or International Cultures categories. At least two courses (18 units) must be from the Institute for Politics and Strategy (84-xxx). Most courses listed below are 9-unit courses, but some are fewer. When courses offered for fewer than 9 units are chosen, students should note that a minimum of 45 units is required, and should plan to take one or more additional courses as appropriate.

OR

Option 2) complete the majority of their electives via the Carnegie Mellon University Washington Semester Program (CMU/WSP) Public Policy elective sequence. Any elective units not fulfilled during CMU/WSP may be completed through coursework from the Grand Strategy and Political Institutions elective list.

The Washington Semester Program (CMUWSP) Public Policy Elective Sequence includes:

- Internship Seminar (12 units)
- Policy Forum (12 units) - This course will count toward the IRP Capstone Policy Forum (84-450) Core Course Requirement.
- Core Seminar (12 units)
- Elective Seminar (12 units)

A list of CMU/WSP Core and Elective Seminars may be found in the CMU/WSP section of the undergraduate catalog (p. 282) below.

Grand Strategy and Political Institutions	Units
19-609 Public Policy and Regulation	9
19-662 Special Topics: Technology and Development in China & India	12
79-203 Social and Political Change in 20th Century Central and Eastern Europe	9
79-218 United States and the World	9
79-231 American Foreign Policy: 1945-Present	9
79-298 Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal	6
79-301 History of Surveillance: From the Plantation to Edward Snowden	6
79-302 Drone Warfare: Ethics, Law, Politics, History, and Strategy	6
79-310 From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-359 Terrorism and U.S. National Security	6
79-360 Conspiracies, Spies, and Assassins in Revolutionary Europe	6
79-389 Stalin and Stalinism	9
79-392 History of Modern Warfare	9
80-135 Introduction to Political Philosophy	9
80-235 Political Philosophy	9
80-321 Causation, Law, and Social Policy	9
80-335 Deliberative Democracy: Theory and Practice	9
84-210 Comparative Political Systems	9
84-320 Domestic Politics and International Affairs	9
84-321 Autocrats and Democrats	9
84-322 Attitudes, the Media, and Conflict in International Relations	9
84-323 War and Peace	9
84-324 Democracies and War	9
84-362 Diplomacy and Statecraft	9
84-380 Grand Strategy in the United States	9
84-386 The Privatization of Force	9
84-389 Terrorism and Insurgency	9
84-393 Legislative Decision Making: U.S. Congress	9
84-402 Judicial Politics and Behavior	9
84-414 International and Subnational Security	9
88-223 Decision Analysis and Decision Support Systems	9
88-281 Topics in Law: 1st Amendment	9
88-284 Topics of Law: The Bill of Rights	9
88-302 Behavioral Decision Making	9
88-388 Psychological Models of Decision Making	9
88-405 Risk Perception and Communication	9
88-415 Global Competitiveness: Firms Nations, and Technological Change	9
88-442 Decision Science in Intergroup Conflict	9
Economics and Society	Units
70-342 Managing Across Cultures	9
70-365 International Trade and International Law	9
70-430 International Management	9
73-148 Environmental Economics	9
73-328 Health Economics	12
73-331 Political Economy of Inequality and Redistribution	9

73-372	International Money and Finance	9	79-381	Energy and Empire: How Fossil Fuels Changed the World	9																																
73-375	History of Money and Monetary Policy	9	79-383	Epidemics, Disease, and Public Health	9																																
73-394	Development Economics	9	79-385	The Making of the African Diaspora	9																																
79-386	Entrepreneurs in Africa, Past, Present and Future	9	79-398	Documenting the 1967 Arab-Israeli War	9																																
80-136	Social Structure, Public Policy & Ethics	9	82-304	The Francophone World	9																																
80-244	Environmental Ethics	9	82-320	Contemporary Society in Germany, Austria and Switzerland	9																																
80-247	Ethics and Global Economics	9	82-323	Germany, Austria and Switzerland in the 20th Century	9																																
80-344	Management, Environment, and Ethics	9	82-333	Introduction to Chinese Language and Culture	Var.																																
80-348	Health Development and Human Rights	9	82-342	Spain: Language and Culture	9																																
80-447	Global Justice	9	82-343	Latin America: Language and Culture	9																																
84-310	International Political Economy and Organizations	9	82-344	U.S. Latinos: Language and Culture	9																																
88-352	Environmental Economics and Policy	9	82-345	Introduction to Hispanic Literary and Cultural Studies	9																																
88-378	International Economics	9	82-361	Italian Language and Culture I	9																																
88-391	Technology and Economic Growth	9	82-362	Italian Language and Culture II	9																																
88-410	The Global Economy: A User's Guide	9	82-431	China and the West	9																																
88-411	Rise of the Asian Economies	9	82-433	Topics in Contemporary Culture of China	9																																
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9	82-441	Studies in Peninsular Literature and Culture	9																																
88-413	Energy and Climate: History, Science, Technology, & Policy in the US 1776-2076	9	82-451	Studies in Latin American Literature and Culture	9																																
88-419	Negotiation	9	82-455	Topics in Hispanic Studies	9																																
88-423	Institutions, Entrepreneurship, and Innovation	9	82-474	Topics in Japanese Studies	9																																
International Cultures		Units	82-541	Special Topics: Hispanic Studies	Var.																																
76-318	Communicating in the Global Marketplace	9	85-375	Crosscultural Psychology	9																																
76-322	Global Masala: South Asians in the Diaspora	9	300 or 400- level language course (at most one for this category)																																		
76-386	Language & Culture	9	NOTE: Some courses have additional prerequisites.																																		
79-205	20th Century Europe	9	International Relations and Politics, B.S.																																		
79-211	East Asia in the World, 1600-Present	9	These sample curricula represent a plan for completing the requirements for the B.S. in International Relations and Politics. International Relations and Politics students are encouraged to spend a semester studying and interning in Washington, DC, through the CMU/WSP (http://www.cmu.edu/ir/washington-semester-program), and/or study abroad. The plan below demonstrates that a semester off-campus fits well into the curriculum. As with most majors in the Dietrich College, the International Relations and Politics major can be completed in as few as two years of undergraduate study, not that it must be. Students may declare the B.S. in International Relations and Politics and take appropriate courses as early as the second semester of the freshman year and as late as the second semester sophomore year, and should consult frequently with the academic program manager (see above) about their course of study.																																		
79-221	Development and Democracy in Latin America	9	<table border="1"> <thead> <tr><th colspan="2">Freshman</th><th colspan="2">Sophomore</th></tr> <tr><th>Fall</th><th>Spring</th><th>Fall</th><th>Spring</th></tr> </thead> <tbody> <tr><td>36-201 Statistical Reasoning and Practice</td><td>76-101 Interpretation and Argument</td><td>84-265 Political Science Research Methods</td><td>84-275 Comparative Politics</td></tr> <tr><td>79-104 Global Histories</td><td>Freshman Seminar</td><td>84-326 Theories of International Relations</td><td>Analytic Methods Prerequisite</td></tr> <tr><td>21-120 Differential and Integral Calculus*</td><td>36-202 Statistical Methods</td><td>Language Course or Gen Ed</td><td>IRP Elective</td></tr> <tr><td>84-104 Decision Processes in American Political Institutions **</td><td>73-100 Principles of Economics or take 88-220 in fall of sophomore year</td><td>IRP Elective</td><td>Language Course or Gen Ed</td></tr> <tr><td>Language Course or Gen Ed</td><td>Language Course or Gen Ed</td><td>Gen Ed or Elective</td><td>Elective</td></tr> <tr><td>99-101 Computing @ Carnegie Mellon</td><td></td><td></td><td></td></tr> </tbody> </table>			Freshman		Sophomore		Fall	Spring	Fall	Spring	36-201 Statistical Reasoning and Practice	76-101 Interpretation and Argument	84-265 Political Science Research Methods	84-275 Comparative Politics	79-104 Global Histories	Freshman Seminar	84-326 Theories of International Relations	Analytic Methods Prerequisite	21-120 Differential and Integral Calculus*	36-202 Statistical Methods	Language Course or Gen Ed	IRP Elective	84-104 Decision Processes in American Political Institutions **	73-100 Principles of Economics or take 88-220 in fall of sophomore year	IRP Elective	Language Course or Gen Ed	Language Course or Gen Ed	Language Course or Gen Ed	Gen Ed or Elective	Elective	99-101 Computing @ Carnegie Mellon			
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99-101 Computing @ Carnegie Mellon																																					
79-222	Between Revolutions: The Development of Modern Latin America	9																																			
79-223	Mexico: From the Aztec Empire to the Drug War	9																																			
79-224	Mayan America	9																																			
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9																																			
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9																																			
79-230	Arab-Israeli Conflict and Peace Process since 1948	9																																			
79-233	The United States and the Middle East since 1945	9																																			
79-235	Caribbean Cultures	9																																			
79-251	India/America: Democracy, Diversity, Development	9																																			
79-255	Irish History	6																																			
79-256	20th Century Germany	9																																			
79-257	Germany and the Second World War	9																																			
79-259	France During World War II	9																																			
79-261	Chinese Culture and Society	9																																			
79-262	Modern China	9																																			
79-264	Tibet in History and Imagination	9																																			
79-265	Russian History: From the First to the Last Tsar	9																																			
79-266	Russian History: From Communism to Capitalism	9																																			
79-267	The Soviet Union in World War II: Military, Political, and Social History	9																																			
79-275	Introduction to Global Studies	9																																			
79-282	Europe and the World since 1800	9																																			
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9																																			
79-291	Globalization in East African History	6																																			
79-299	Trafficking Persons: Children in a Global Context	9																																			
79-307	Religion and Politics in the Middle East	9																																			
79-312	International Human Rights Institutions in Theory and Practice	6																																			
79-314	The Politics and Culture of Memory	9																																			
79-320	Women, Politics, and Protest	9																																			
79-338	History of Education in America	9																																			
79-342	Introduction to Science and Technology Studies	9																																			
79-377	Food, Culture, and Power: A History of Eating	9																																			

*If required to start with 21-111 in fall of freshman year, complete 21-112 in spring of freshman year.

**This course should be taken as the first course in the International Relations and Politics major sequence. It is intended for students in their first or second years.

Junior		Senior	
Fall	Spring	Fall	Spring
IRP Elective	CMU/WSP or STUDY ABROAD*	66-501 H&SS Senior Honors Thesis I**	84-450 IRP Capstone Policy Forum
Language Course or Elective	IRP Elective	IRP Elective	66-502 H&SS Senior Honors Thesis II**
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective
Elective	Elective	Elective	Elective

*All students are strongly encouraged to participate in the CMU/WSP (<http://www.cmu.edu/ir/washington-semester-program>) and/or in a study abroad program. Spring semester of the junior year is a popular semester to study off-campus. However, International Relations and Politics majors may instead choose to participate in the CMU/WSP or study abroad in spring of sophomore year, fall of junior year, or fall of senior year. Students should consult the academic advisor when planning their curricular program.

**Students are not required to complete a college honors thesis. However, many International Relations and Politics majors choose to apply for the senior honors thesis program. Students who do not pursue a senior honors thesis should select an elective in its place.

Additional Major

Students who elect International Relations and Politics as an additional major must fulfill all of the requirements of the International Relations and Politics major.

Minor in International Relations and Politics

The International Relations and Politics (IRP) minor analyzes the role of politics at the national, regional, international, and transnational levels; examines political and institutional arrangements within and among these levels; and investigates the grand strategy of nation-states.

Statesmen, scholars, and policy makers often define grand strategy as the combination of diplomatic, economic, military, and political factors used by leaders to defend their respective nation-states. The IRP minor investigates the way in which leaders and citizens construct grand strategy and national security policy more generally; the impact of domestic and international forces on states' security and economic policies; and the significance of alliances, coalitions, and international institutions for world politics. The study of grand strategy and political institutions is the flagship initiative of the minor.

In the tradition of Carnegie Mellon University, political science is studied and taught in an interdisciplinary manner. Utilizing the interdisciplinary strengths of the social sciences at CMU, IRP students study political phenomena through the perspectives of behavioral decision science, complex social systems, economics, strategy, entrepreneurship and technological change, and political history. Students pursuing the minor may find it helpful to develop their analytical tools of game theory, economic and statistical analysis, qualitative analysis, rational choice theory, and theories of behavioral decision making as they study alliances, coalitions, institutions, and political strategy. Recognizing the influence of language and culture on politics and international relations, students are encouraged to study a modern language other than English.

The International Relations and Politics minor is offered through the Institute for Politics and Strategy. It is available as a minor in the Dietrich College of Humanities and Social Sciences.

Prerequisites

73-100	Principles of Economics	9
or 88-220	Policy Analysis I	

Curriculum

54 units

Students must take all three core courses (27 units):

84-104	Decision Processes in American Political Institutions	9
84-275	Comparative Politics	9

84-326	Theories of International Relations	9
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Students select three courses (27 units) from any of the elective sequences below. Two courses must be taken from the Institute for Politics and Strategy and have an 84-number course:

Grand Strategy and Political Institutions		
19-609	Public Policy and Regulation	9
19-662	Special Topics: Technology and Development in China & India	12
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-218	United States and the World	9
79-231	American Foreign Policy: 1945-Present	9
79-298	Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal	6
79-301	History of Surveillance: From the Plantation to Edward Snowden	6
79-302	Drone Warfare: Ethics, Law, Politics, History, and Strategy	6
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-359	Terrorism and U.S. National Security	6
79-360	Conspiracies, Spies, and Assassins in Revolutionary Europe	6
79-389	Stalin and Stalinism	9
79-392	History of Modern Warfare	9
80-135	Introduction to Political Philosophy	9
80-235	Political Philosophy	9
80-321	Causation, Law, and Social Policy	9
80-335	Deliberative Democracy: Theory and Practice	9
84-210	Comparative Political Systems	9
84-320	Domestic Politics and International Affairs	9
84-321	Autocrats and Democrats	9
84-322	Attitudes, the Media, and Conflict in International Relations	9
84-323	War and Peace	9
84-324	Democracies and War	9
84-362	Diplomacy and Statecraft	9
84-380	Grand Strategy in the United States	9
84-386	The Privatization of Force	9
84-389	Terrorism and Insurgency	9
84-393	Legislative Decision Making: U.S. Congress	9
84-402	Judicial Politics and Behavior	9
84-414	International and Subnational Security	9
88-223	Decision Analysis and Decision Support Systems	9
88-281	Topics in Law: 1st Amendment	9
88-284	Topics in Law: The Bill of Rights	9
88-302	Behavioral Decision Making	9
88-388	Psychological Models of Decision Making	9
88-405	Risk Perception and Communication	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9
88-442	Decision Science in Intergroup Conflict	9
Economics and Society		
70-342	Managing Across Cultures	9
70-365	International Trade and International Law	9
70-430	International Management	9
73-148	Environmental Economics	9
73-328	Health Economics	12
73-331	Political Economy of Inequality and Redistribution	9
73-372	International Money and Finance	9
73-375	History of Money and Monetary Policy	9
73-394	Development Economics	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
80-136	Social Structure, Public Policy & Ethics	9
80-244	Environmental Ethics	9
80-247	Ethics and Global Economics	9
80-344	Management, Environment, and Ethics	9
80-348	Health Development and Human Rights	9

80-447	Global Justice	9	82-333	Introduction to Chinese Language and Culture	Var.
84-310	International Political Economy and Organizations	9	82-342	Spain: Language and Culture	9
88-352	Environmental Economics and Policy	9	82-343	Latin America: Language and Culture	9
88-378	International Economics	9	82-344	U.S. Latinos: Language and Culture	9
88-391	Technology and Economic Growth	9	82-345	Introduction to Hispanic Literary and Cultural Studies	9
88-410	The Global Economy: A User's Guide	9	82-361	Italian Language and Culture I	9
88-411	Rise of the Asian Economies	9	82-362	Italian Language and Culture II	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9	82-433	Topics in Contemporary Culture of China	9
88-413	Energy and Climate: History, Science, Technology, & Policy in the US 1776-2076	9	82-441	Studies in Peninsular Literature and Culture	9
88-419	Negotiation	9	82-451	Studies in Latin American Literature and Culture	9
88-423	Institutions, Entrepreneurship, and Innovation	9	82-455	Topics in Hispanic Studies	9
International Cultures			82-474	Topics in Japanese Studies	9
76-318	Communicating in the Global Marketplace	9	82-541	Special Topics: Hispanic Studies	Var.
76-322	Global Masala: South Asians in the Diaspora	9	85-375	Crosscultural Psychology	9
76-386	Language & Culture	9	Minor in Politics and Public Policy		
79-205	20th Century Europe	9	Rooted in the discipline of political science, the minor in Politics and Public Policy investigates U.S. public policy issues and other matters of domestic politics while providing students hands-on and practical learning experiences. Students pursuing the Politics and Public Policy minor must participate in the Carnegie Mellon University Washington Semester Program for one semester during their undergraduate experience.		
79-211	East Asia in the World, 1600-Present	9	From embassy headquarters to nongovernmental organizations, think tanks to advocacy organizations, and consulting firms to media outlets, Washington, DC, is a focal point for many international and public policy activities. Open to all Carnegie Mellon undergraduates, the Carnegie Mellon University Washington Semester Program (CMU/WSP) allows students to study public policy and intern in Washington for one semester. Undergraduates from any course of study who would value firsthand policy experience are invited to apply to the Carnegie Mellon University Washington Semester Program and declare a minor in Politics and Public Policy.		
79-221	Development and Democracy in Latin America	9	As a member of the University of California Washington Center (UCDC) consortium of schools, CMU/WSP is part of a broad and diverse intellectual community of faculty and students. In this semester-long program, students live, work, and study in Washington, DC, coming into direct contact with political, business, and community leaders and learning about the most pressing policy issues of the day.		
79-222	Between Revolutions: The Development of Modern Latin America	9	Students earn 48 units for the Carnegie Mellon University Washington Semester Program, interning three days per week in any sector or field of interest within Washington, DC, while taking classes two days per week and in the evenings. Courses are offered by CMU and UCDC faculty. The Center for International Relations and Politics sponsors events and a policy forum in Washington for students participating in the program to further enrich their experience and enhance their understanding of how Washington functions as a hub of international and public policy decision making. UCDC also provides policy-oriented events.		
79-223	Mexico: From the Aztec Empire to the Drug War	9	The minor in Politics and Public Policy is offered through the Institute for Politics and Strategy in the Dietrich College of Humanities and Social Sciences.		
79-224	Mayan America	9	Prerequisites		
79-227	African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid	9	73-100	Principles of Economics	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9	or 88-220	Policy Analysis I	
79-230	Arab-Israeli Conflict and Peace Process since 1948	9	Curriculum		
79-233	The United States and the Middle East since 1945	9	57 units		
79-235	Caribbean Cultures	9	All students must take the following two courses while participating in the CMU/WSP (24 units):		
79-251	India/America: Democracy, Diversity, Development	9	84-360	CMU/WSP: Internship Seminar	12
79-255	Irish History	6	84-450	IRP Capstone Policy Forum	12
79-256	20th Century Germany	9	Students select one core seminar from the following list of courses offered in the CMU/WSP (12 units):		
79-257	Germany and the Second World War	9	84-330	CMU/WSP: The United States Supreme Court	12
79-259	France During World War II	9	84-331	CMU/WSP: Congress	12
79-261	Chinese Culture and Society	9	84-332	CMU/WSP: Washington Media	12
79-262	Modern China	9	84-333	CMU/WSP: General Research Seminar	12
79-264	Tibet in History and Imagination	9	84-334	CMU/WSP: International Policy	12
79-265	Russian History: From the First to the Last Tsar	9	84-336	CMU/WSP: The Presidency and Executive Branch	12
79-266	Russian History: From Communism to Capitalism	9			
79-267	The Soviet Union in World War II: Military, Political, and Social History	9			
79-275	Introduction to Global Studies	9			
79-282	Europe and the World since 1800	9			
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9			
79-291	Globalization in East African History	6			
79-299	Trafficking Persons: Children in a Global Context	9			
79-307	Religion and Politics in the Middle East	9			
79-312	International Human Rights Institutions in Theory and Practice	6			
79-314	The Politics and Culture of Memory	9			
79-320	Women, Politics, and Protest	9			
79-338	History of Education in America	9			
79-342	Introduction to Science and Technology Studies	9			
79-377	Food, Culture, and Power: A History of Eating	9			
79-381	Energy and Empire: How Fossil Fuels Changed the World	9			
79-383	Epidemics, Disease, and Public Health	9			
79-385	The Making of the African Diaspora	9			
79-398	Documenting the 1967 Arab-Israeli War	9			
82-304	The Francophone World	9			
82-320	Contemporary Society in Germany, Austria and Switzerland	9			
82-323	Germany, Austria and Switzerland in the 20th Century	9			

Students select one elective seminar from the following list of courses offered in the CMU/WSP (12 units):

84-340	CMU/WSP: American Political Journalism	12
84-341	CMU/WSP: U.S. Foreign Policy in the Middle East	12
84-342	CMU/WSP: Fiscal Policy-Making in the U.S.	12
84-343	CMU/WSP: Sports, Politics, and Society	12
84-344	CMU/WSP: Politics and Poems: Writing Verse in DC	12
84-345	CMU/WSP: Cultural Policy: Cultural Heritage and Cultural Diplomacy	12
84-346	CMU/WSP: Race and Politics in the American City	12
84-347	CMU/WSP: Lobbying, Money, and Influence in Washington	12
84-348	CMU/WSP: Spies! The Politics of Intelligence	12
84-349	CMU/WSP: The Theater of Politics	12
84-350	CMU/WSP: Campaigns and Elections	12

Students select one course from the following list of courses offered at Carnegie Mellon University's Pittsburgh or Qatar campus. Students may take this course before or after participating in the CMU/WSP. (9 units):

84-104	Decision Processes in American Political Institutions	9
84-275	Comparative Politics	9
84-326	Theories of International Relations	9

Carnegie Mellon University Washington Semester Program

Kiron Skinner, Faculty Director; kskinner@andrew.cmu.edu, Porter Hall 223E
Emily Half, Academic Program Manager; ehalf@andrew.cmu.edu;
412-268-7082, Baker Hall A60C
Emily Baddock, Program Director in Washington, DC;
ebaddock@andrew.cmu.edu; 202-608-8316, 100 Maryland Ave NE, Suite 510, Washington, DC 20002

<http://www.cmu.edu/ir/washington-semester-program/index.html>

From embassy headquarters to nongovernmental organizations, think tanks to advocacy organizations, and consulting firms to media outlets, Washington, DC, is a focal point for many international and public policy activities.

Undergraduates from any course of study who would value firsthand policy experience are invited to apply to the Carnegie Mellon University Washington Semester Program (CMU/WSP), sponsored by the university's Institute for Politics and Strategy. As a member of the University of California Washington Center (UCDC) consortium of schools, CMU/WSP is part of a broad and diverse intellectual community of faculty and students. In this semester-long program, students live, work, and study in Washington, DC, coming into direct contact with political, business, and community leaders and learning about the most pressing policy issues of the day.

CMU/WSP students earn 48 units for their semester in Washington, interning three days per week in any sector or field of interest within Washington, DC, while taking classes two days per week and in the evenings. Courses are offered by Carnegie Mellon and UCDC faculty. The Institute for Politics and Strategy sponsors events and a policy forum in Washington for students participating in the program to further enrich their experience and enhance their understanding of how Washington functions as a hub of international and public policy decision making. UCDC also provides policy-oriented events.

Students should contact the academic program manager for more information or to discuss how the CMU/WSP may fit into their curriculum.

Curriculum

All students enroll in the following two courses.

84-360	CMU/WSP: Internship Seminar	12
84-450	IRP Capstone Policy Forum	12

Students select one core seminar from the following list.

84-330	CMU/WSP: The United States Supreme Court	12
84-331	CMU/WSP: Congress	12
84-332	CMU/WSP: Washington Media	12
84-333	CMU/WSP: General Research Seminar	12

84-334	CMU/WSP: International Policy	12
84-336	CMU/WSP: The Presidency and Executive Branch	12

Students select one elective seminar from the following list.

Elective Seminar

84-340	CMU/WSP: American Political Journalism	12
84-341	CMU/WSP: U.S. Foreign Policy in the Middle East	12
84-342	CMU/WSP: Fiscal Policy-Making in the U.S.	12
84-343	CMU/WSP: Sports, Politics, and Society	12
84-344	CMU/WSP: Politics and Poems: Writing Verse in DC	12
84-345	CMU/WSP: Cultural Policy: Cultural Heritage and Cultural Diplomacy	12
84-346	CMU/WSP: Race and Politics in the American City	12
84-347	CMU/WSP: Lobbying, Money, and Influence in Washington	12
84-348	CMU/WSP: Spies! The Politics of Intelligence	12
84-349	CMU/WSP: The Theater of Politics	12
84-350	CMU/WSP: Campaigns and Elections	12

Executive Committee and Affiliated Faculty

KIRON K. SKINNER, Associate Professor of International Relations and Political Science; Institute Director – Ph.D., Harvard University; Carnegie Mellon, 1999–.

BARUCH FISCHHOFF, Howard Heinz University Professor of Social and Decision Sciences and of Engineering and Public Policy – Ph.D., The Hebrew University of Jerusalem; Carnegie Mellon, 1987–.

MARK S. KAMLET, University Professor of Economics and Public Policy and Provost Emeritus – Ph.D., University of California, Berkeley; Carnegie Mellon, 1978–.

ALLAN H. MELTZER, The Allan H. Meltzer University Professor of Political Economy – Ph.D., University of California, Los Angeles; Carnegie Mellon, 1957–.

Lecturers

COLIN P. CLARKE, Lecturing Faculty in International Relations and Politics – Ph.D., University of Pittsburgh; Carnegie Mellon, 2014–.

MOLLY DUNIGAN, Lecturing Faculty in International Relations and Politics – Ph.D., Cornell University; Carnegie Mellon, 2014–.

GEOFFREY MCGOVERN, Lecturing Faculty in International Relations and Politics – Ph.D., Binghamton University., J.D., Harvard University; Carnegie Mellon, 2013–.

Fellows

THOMAS KARAKO, Fellow in the Institute for Politics and Strategy – Ph.D., Claremont Graduate University; Carnegie Mellon, 2015–.

Post-Doctoral Fellows

ANDREW BAUSCH, Post-Doctoral Fellow in International Relations and Politics – Ph.D., New York University; Carnegie Mellon, 2013–.

KAZUTO OHTSUKI, Post-Doctoral Fellow in International Relations and Politics – Ph.D., New York University; Carnegie Mellon, 2014–.

ANNA PECHENKINA, Post-Doctoral Fellow in International Relations and Politics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2013–.

Department of Psychology

Michael Tarr, Department Head
Department Office: Baker Hall 346-C
<http://www.psy.cmu.edu>

Can newborn infants perceive the world as we do, or is it just "a blooming buzzing confusion"? Do personality, beliefs and social factors influence health? How do scientists and young children make discoveries, and what abilities make these insights possible? How does brain activity reveal differences in thinking? Can computers think the way people do?

These are some of the questions that psychologists at Carnegie Mellon are trying to answer.

For the student who is majoring in Psychology, Cognitive Science or Neuroscience, studying with faculty who are on the leading edge of research on questions like the above can be a very exciting experience.

The Psychology Department at Carnegie Mellon has long been noted as one of the pioneering Psychology Departments in the world, particularly in such areas as cognitive psychology, cognitive science, social psychology, developmental psychology, cognitive neuroscience, and health psychology. The Psychology Department offers 5 majors: B.A. and B.S. degrees in Psychology, as well as a B.S. degree in Cognitive Science and together with the Department of Biological Sciences, a unified B.S. double major in Psychology and Biological Sciences, and an Intercollege major in Neuroscience.

The Major in Psychology

Psychology is a discipline that embraces both biological and social sciences. It is a science concerned with establishing principles and laws regarding the ways in which people think and behave through the scientific study of human behavior.

The orientation of the Carnegie Mellon Psychology curriculum is toward developing highly skilled and knowledgeable graduates. About half of our graduates go on to graduate or professional school. The remainder seek to expand their problem-oriented analytic skills to qualify themselves for job opportunities beyond those typically open to liberal arts students.

Majors in the department are expected not only to learn about findings already established by psychologists, but also to become proficient in the investigation and analysis of behavior. This includes observing behavior, formulating hypotheses, designing experiments to test these hypotheses, running experiments, performing statistical analysis, and writing reports. The department has many resources for students to use in acquiring these skills. For instance, students interested in child development may be involved in the child development laboratory and observational facilities which are a part of the Carnegie Mellon Children's School which operates under the department's aegis. Students interested in health or clinical psychology might have opportunities to do internships in applied settings, and all Psychology majors have access to extensive computer facilities for data analysis and simulation work. The department also has a state of the art set of undergraduate research laboratories and computer clusters, and through the Scientific Imaging & Brain Research Center, a magnet is in use for conducting brain imaging studies using fMRI.

In addition to formal class work, students are encouraged to participate in elective research projects where they may register and receive credit for freshmen research experience course, 85-506 Readings in Psychology, Fall research experience in 85-507 Research in Psychology or Spring research experience in 85-508 Research in Psychology. In the research in psychology course, the student may work on an ongoing research project or develop and carry out a new research project with a faculty member. There is university and departmental funding available to help support student-initiated research projects and student travel to present research results at scientific meetings and conferences. In the Readings courses, the student reads extensively on a particular topic. The faculty member and student meet to discuss the readings, and the student writes a paper on the topic selected. The Psychology Department Website (<http://www.psy.cmu.edu>), provides descriptions of faculty (<http://www.psy.cmu.edu/people/faculty.html>) research interests that the student can use in determining who should be approached to supervise a particular research or reading project.

Students interested in gaining field work experience via a number of internship opportunities available to them can receive credit through 85-482 Internship in Psychology, 85-480 Internship in Clinical Psychology or 85-484 Practicum in Child Development. Clinical internships are available with a variety of clinical settings including the prestigious Western Psychiatric

Institute and Clinic (the teaching hospital of the Department of Psychiatry at the University of Pittsburgh Medical School). During the internship, students get first-hand experience with different clinical populations. Developmental Practicum experience is available in the department-run CMU Children's School (<http://www.psy.cmu.edu/cs>).

Psychology Curriculum

Mathematics 19-20 units

21-111-21-112 Calculus I-II 20

or

21-120-21-122 Differential and Integral Calculus - Integration and Approximation 20

or

21-120-21-256 Differential and Integral Calculus - Multivariate Analysis 19

*Students who place out of 21-120 with AP credit are only required to successfully complete 21-122 or 21-256 instead of the full two semester sequence.

*21-124 may be substituted for 21-122 for those interested in Neuroscience or Biology.

Statistics Sequence 18 units

36-201	Statistical Reasoning and Practice	9
36-309	Experimental Design for Behavioral and Social Sciences	9

*In certain circumstances, 36-202 can be a substitute for 36-309.

Breadth Requirement 36 units

85-102	Introduction to Psychology *	9
Survey Courses - Complete Three		
85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	
85-219	Biological Foundations of Behavior	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9

* A fourth survey course can be taken in place of Introduction to Psychology

Research Methods* 18 units

Complete two courses.

85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	9
85-330	Analytic Research Methods	9
85-340	Research Methods in Social Psychology	9

* Prerequisites for all Research Methods courses: 36-309 or equivalent, and corresponding survey course.

Advanced Courses 18 units

Advanced psychology courses exist within four areas (cognitive, cognitive neuroscience, developmental, social and health psychology.) Any advanced content course or seminar in psychology or any psychology course higher than 85-350. Exceptions for the advanced course requirement are: 85-480, 85-482, 85-484, 85-484, 85-506, 85-507, 85-508, 85-601, 85-602, 66-501, 66-502.

Computer Science Requirement 10 units

15-110	Principles of Computing	10
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Natural Science Requirement (B.A. 18 units, B.S. 36 units, both of which include 9 units of GenEd Science)

The Psychology major requires (for B.S. candidates) three additional natural science courses (with two in the same science) beyond the College's General Education natural science requirement. For the B.A. the requirement is one course beyond the General Education requirement in natural science.

These courses can be selected from the following areas:

03-XXX	Biology*
09-XXX	Chemistry
33-XXX	Physics

*Given the growing relevance of biology to psychology, it is strongly recommended that for the B.S. a minimum of two courses in biology be included as part of the natural science requirement.

Additional Major in Psychology

In order to complete an additional major in Psychology, a student must fulfill all of the Psychology major requirements within the department -- in other words, the breadth requirement, computing requirement, three survey courses at the 200-level, two research methods courses, and two advanced courses. These courses must include at least 81 units, plus calculus prerequisites and the 36-201 statistics course or equivalent and 36-309. In addition, B.S. candidates must take the three-course science requirement and B.A. candidates complete one science course beyond the GenEd requirement.

Concentrations within the Psychology Major

Students who wish to focus their Psychology program on a specific area can do so either by the careful selection of Psychology elective courses focusing on their area of interest or by pursuing one of the following concentrations. Students must obtain a concentration form from the Undergraduate Program Coordinator, Emilie O'Leary, receive approval from their psychology faculty advisor, then returning the signed copy to Emilie in Baker Hall 339. The completion of a concentration will be recognized in the Psychology Graduation Brochure.

Health-Psychology Concentration

For Psychology majors who wish to have a focus of their study on Health Psychology, the following courses should be selected as part of their Psychology Major in conjunction with their Psychology advisor's approval.

As part of the B.S. science requirement:

- 03-121 Modern Biology
- + one additional Biology course

As part of the psychology breadth requirement:

- 85-219 Biological Foundations of Behavior
- 85-241 Social Psychology

As part of the psychology Research Methods requirement:

- 85-340 Research Methods in Social Psychology

As part of the advanced coursework in psychology requirement, at least two of the following:

- 85-442 Health Psychology
- 85-443 Social Factors and Well-Being
- 85-446 Psychology of Gender
- 85-501 Stress, Coping and Well-Being

Cognitive-Neuroscience Concentration

For Psychology majors who wish to have a focus of their study be on Cognitive Neuroscience, the following courses should be selected as part of their Psychology Major in conjunction with their Psychology advisor's approval.

As part of the B.S. Science requirement:

- 03-121 Modern Biology
- 03-363 Systems Neuroscience

As part of the psychology Breadth requirement:

- 85-211 Cognitive Psychology
- 85-219 Biological Foundations of Behavior

As part of the Research Methods requirement:

- 85-310 Research Methods in Cognitive Psychology
- 85-314 Cognitive Neuroscience Research Methods

As part of the advanced coursework in psychology requirement, at least two of the following:

- 85-356 Music and Mind: The Cognitive Neuroscience of Sound
- 85-370 Perception
- 85-406 Autism: Psychological and Neuroscience Perspectives
- 85-414 Cognitive Neuropsychology
- 85-419 Introduction to Parallel Distributed Processing
- 85-429 Cognitive Brain Imaging

Developmental Psychology Concentration

For Psychology majors who wish to have a focus of their study be on Developmental Psychology, the following courses should be selected as part of their Psychology Major in conjunction with their Psychology advisor's approval.

As part of the B.S. science requirement:

- 03-121 Modern Biology

As part of the psychology Breadth requirement:

- 85-221 Principles of Child Development

As part of the psychology Research Methods Requirement:

- 85-320 Research Methods in Developmental Psychology

As part of the advanced coursework in psychology requirement, at least two of the following:

- 85-354 Infant Language Development
- 85-363 Attention, Its Development and Disorders
- 85-406 Autism: Psychological and Neuroscience Perspectives
- 85-423 Cognitive Development

Additional course requirement, one of the following:

- 85-484 Practicum in Child Development
- 03-350 Developmental Biology

Cognitive Psychology Concentration

For Psychology majors who wish to have a focus of their study be on Cognitive Psychology and/or Cognitive Modeling, the following courses should be selected as part of their Psychology Major in conjunction with their Psychology advisor's approval.

As part of the B.S. science requirement:

- 03-121 Modern Biology

As part of the psychology Breadth requirement:

- 85-211 Cognitive Psychology

As part of the psychology Research Methods requirement:

- 85-310 Research Methods in Cognitive Psychology

As part of the advanced coursework in psychology requirement, at least two of the following:

- 85-355 Introduction to Cognitive Neuroscience
- 85-356 Music and Mind: The Cognitive Neuroscience of Sound
- 85-370 Perception
- 85-380 In Search of Mind: The History of Psychology
- 85-390 Human Memory
- 85-392 Human Expertise
- 85-395 Applications of Cognitive Science
- 85-406 Autism: Psychological and Neuroscience Perspectives
- 85-412 Cognitive Modeling

- 85-414 Cognitive Neuropsychology
- 85-419 Introduction to Parallel Distributed Processing
- 85-421 Language and Thought
- 85-426 Learning in Humans and Machines
- 85-429 Cognitive Brain Imaging

Social-Personality Psychology Concentration

For Psychology majors who wish to have a focus of their study be on Social and/or Personality Psychology, the following courses should be selected as part of their Psychology Major in conjunction with their Psychology advisor's approval.

As part of the Psychology Breadth requirement:

- 85-241 Social Psychology
- 85-251 Personality

As part of the Psychology Research Methods requirement:

- 85-340 Research Methods in Social Psychology

As part of the advanced coursework in psychology requirement, at least two of the following:

- 85-352 Evolutionary Psychology
- 85-358 Pro-Social Behavior
- 85-375 Crosscultural Psychology
- 85-377 Attitudes and Persuasion
- 85-443 Social Factors and Well-Being
- 85-444 Relationships
- 85-446 Psychology of Gender
- 85-501 Stress, Coping and Well-Being

Clinical/Counseling Psychology Concentration

For Psychology majors who wish to have a focus of their study be on Clinical/Counseling Psychology, the following courses should be selected as part of their Psychology Major in conjunction with their Psychology advisor's approval.

As part of the Psychology Breadth requirement at least one of the following:

- 85-241 Social Psychology
- 85-251 Personality

Required additional coursework:

- 85-261 Abnormal Psychology
- 85-281 Introduction to Clinical Psychology
- 85-480 Internship in Clinical Psychology

As part of the Psychology Research Methods requirements:

- 85-340 Research Methods in Social Psychology

As part of the advanced coursework in psychology requirement, at least two of the following:

- 85-375 Crosscultural Psychology
- 85-377 Attitudes and Persuasion
- 85-406 Autism: Psychological and Neuroscience Perspectives
- 85-414 Cognitive Neuropsychology
- 85-425 Child Psychopathology and Treatment
- 85-442 Health Psychology
- 85-443 Social Factors and Well-Being
- 85-444 Relationships
- 85-446 Psychology of Gender
- 85-481 Seminar in Intervention
- 85-501 Stress, Coping and Well-Being

Neuroscience Major

The Psychology Department at Carnegie Mellon University has a major focus on the role of the brain and nervous system in cognition and behavior, including biological approaches involving the health impact that arises from the interaction of behavior with the nervous, endocrine, and immune systems. These interests are manifested in faculty research (<http://www.psy.cmu.edu>), departmental and university centers that operate from or heavily involve the department (e.g., the Center for Cognitive Brain Imaging (<http://www.ccbi.cmu.edu>), and the Center for the Neural Basis of Cognition (<http://www.cnbc.cmu.edu>)) as well as undergraduate coursework (http://www.psy.cmu.edu/undergrad_program) and graduate coursework.

For undergraduates, there are a number of ways in which students with an interest in these approaches can pursue that interest in an organized fashion.

Carnegie Mellon University recently launched *BrainHub* – an initiative designed to leverage its core strengths in cognitive science, engineering, and computer science, and our emerging excellence in biological sciences, to harness the technology that helps the world explore brain and behavior. Students will be able to take advantage of exciting opportunities such as lectures hosted on various topics, newly funded CMU campus research projects trying to answer pressing questions in brain science and the many global partnerships with other institutions all with the same motivating goal to enhance and increase research in brain sciences.

Finally, for any interested student, there is a minor in Cognitive Neuroscience available through the Psychology department (see below).

Unified Double Major in Psychology & Biological Sciences

This major is intended to reflect the interdisciplinary nature of current research in the fields of biology and psychology, as well as the national trend in some professions to seek individuals broadly trained in both the social and natural sciences.

Note: Students entering from the College of Humanities and Social Sciences will earn a Bachelor of Science in Psychology and Biological Sciences. Students in the Mellon College of Science will earn a Bachelor of Science in Biological Sciences and Psychology. Students in the joint Science and Humanities Scholars (SHS) program can complete the SHS educational core and choose either departmental order for their diploma.

Depending on a student's home college (H&SS or MCS), General Education (GenEd) requirements will be different. GenEd requirements for H&SS (p. 202) and MCS (p. 307) are found on their respective Catalog pages.

Degree Requirements:

Biological Sciences		Units
03-121	Modern Biology	9
03-231	Biochemistry I	9
03-240	Cell Biology	9
03-330	Genetics	9
03-343	Experimental Techniques in Molecular Biology	12
03-411	Topics in Research	1
03-412	Topics in Research	1
03-xxx	General Biology Elective	9
03-3xx	Advanced Biology Elective	9
03-3xx	Advanced Biology Elective	9
Total Biology units		77
Mathematics, Statistics, Physics and Computer Science		Units
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
36-247	Statistics for Lab Sciences	9
or 36-201	Statistical Reasoning and Practice	
36-309	Experimental Design for Behavioral and Social Sciences	9
33-111	Physics I for Science Students MCS students must complete Physics II also (either 33-112 or 33-122)	12
15-110	Principles of Computing *	10

99-10x	Computing at Carnegie Mellon	3
Total Science units		63
Chemistry		Units
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
or 09-219	Modern Organic Chemistry	
09-218	Organic Chemistry II	9
or 09-220	Modern Organic Chemistry II	
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
Total Chemistry units		62
Psychology Courses		Units
85-102	Introduction to Psychology	9
85-219	Biological Foundations of Behavior	9
85-2xx	Survey Psychology Courses**	18
85-310	Research Methods in Cognitive Psychology	9
or 85-340	Research Methods in Social Psychology	
or 85-320	Research Methods in Developmental Psychology	
or 85-314	Cognitive Neuroscience Research Methods	
or 85-330	Analytic Research Methods	
85-3xx	Advanced Psychology Electives	18
Total Psychology units		63
** Excluding 85-261 Abnormal Psychology		
Additional Advanced Elective		
9 units(Choose one of the following courses)		
85-3xx	Advanced Psychology Elective	9
or		
03-3xx	Advanced Biology Elective	9
Additional Laboratory or Research Methods		
9-12 units(Choose one of the following courses)		
03-344	Experimental Biochemistry	12
03-345	Experimental Cell and Developmental Biology	12
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	9
85-340	Research Methods in Social Psychology	9
Elective Units		Units
Free Electives		33-36
MCS Nontechnical Breadth or DC General Education requirements		36-48
Total Elective units		0
360		

Minimum number of units required for degree:

The Major in Cognitive Science

The Psychology Department offers a B.S. degree in Cognitive Science. The field of cognitive science has grown out of increasingly active interaction among psychology, linguistics, artificial intelligence, philosophy, and neuroscience. All of these fields share the goal of understanding intelligence. By combining these diverse perspectives, students of cognitive science are able to understand cognition at a deep level. Because this major is administered by the Psychology Department, it focuses on human cognition and the experimental study of the human mind as illuminated by the techniques of the above disciplines.

Cognitive Science Curriculum

The Cognitive Science major is only offered as a B.S. degree. Candidates should complete before the junior year the two-semester calculus sequence 21-120 /21-256 (or alternatively 21-120/21-122)* and a statistics sequence (36-201 or equivalent and if possible, 36-309). In addition, candidates complete 15-112 Fundamentals of Programming and Computer Science, as their departmental computing course.

Because of the number and sequential nature of required courses, prospective Cognitive Science majors are encouraged to begin course work for the major prior to junior year. In particular, completion of calculus, 36-201, and 85-211 or 85-213 before the junior year will enable students to complete 85-310 and 36-309 and by the Fall semester of their sophomore or junior year and, if interested, to then take advantage of research opportunities in the department.

*The 3-Semester sequence 21-111 /21-112/21-256 may be substituted by students who have already taken 21-111 before deciding on the major.

Computing Prerequisite10 units

15-112	Fundamentals of Programming and Computer Science	12
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Mathematics29-30 units

21-120-21-122	Differential and Integral Calculus - Integration and Approximation	20
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or

21-120-21-256	Differential and Integral Calculus - Multivariate Analysis	19
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21-127	Concepts of Mathematics	10
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*Students who place out of 21-120 are only required to successfully complete 21-122 or 21-256 instead of the full two-semester sequence.

Statistics Sequence18 units

36-201	Statistical Reasoning and Practice	9
36-309	Experimental Design for Behavioral and Social Sciences	9

Computational/Cognitive Modeling Core29-31 units

Two of the following:		Units
15-122	Principles of Imperative Computation	10
15-150	Principles of Functional Programming	10
15-251	Great Theoretical Ideas in Computer Science	12

Plus one of the following:

85-412	Cognitive Modeling	9
85-419	Introduction to Parallel Distributed Processing	9
85-426	Learning in Humans and Machines	9

Cognitive Psychology Core27 units

		Units
85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	
85-310	Research Methods in Cognitive Psychology	9

Plus one of the following:

85-219	Biological Foundations of Behavior	9
85-355	Introduction to Cognitive Neuroscience	9
85-414	Cognitive Neuropsychology	9

Cognitive Science Concentration

(4 courses, concentration approval required)

These four courses are chosen in conjunction with your advisor to form a coherent area of concentration from the course list under "Cognitive Science Concentration" in the current Undergraduate Catalog. Before proceeding with the choice of courses, students must fill out the concentration form, obtained from Emilie O'Leary in Baker Hall 339, with a description of the concentration area and the planned set of four courses. Courses not represented on the list may, with pre-approval of advisor and department, be used to satisfy part of this requirement. The four courses are not required to be within any single category below but be coherent within the major and the focus may vary across disciplinary boundaries.

Computer Science36 units

15-385	Introduction to Computer Vision	6
15-453	Formal Languages, Automata, and Computability	9
10-601	Introduction to Machine Learning	12
05-410	User-Centered Research and Evaluation	12

05-432 Personalized Online Learning 12

Psychology

85-219	Biological Foundations of Behavior	9
85-352	Evolutionary Psychology	9
85-354	Infant Language Development	9
85-355	Introduction to Cognitive Neuroscience	9
85-370	Perception	9
85-375	Crosscultural Psychology	9
85-380	In Search of Mind: The History of Psychology	9
85-390	Human Memory	9
85-392	Human Expertise	9
85-395	Applications of Cognitive Science	9
85-406	Autism: Psychological and Neuroscience Perspectives	9
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing	9
85-421	Language and Thought	9
85-423	Cognitive Development	9
85-426	Learning in Humans and Machines	9
85-429	Cognitive Brain Imaging	9

Philosophy

80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-220	Philosophy of Science	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-270	Philosophy of Mind	9
80-310	Formal Logic	9
80-311	Undecidability and Incompleteness	9
80-314	Logic and Artificial Intelligence	9

Linguistics

76-385	Introduction to Discourse Analysis	9
80-280	Linguistic Analysis	9

Decision Sciences

88-302	Behavioral Decision Making	9
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Neurosciences

03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
42-202	Physiology	9
15-386	Neural Computation	9
15-883	Computational Models of Neural Systems	12

Science Requirement 18 units (minimum)

The Cognitive Science program requires two additional science courses (in the same science) beyond the college's two-course Science General Education requirement.

These can be selected from any one of the following areas.

03-xxx	Biology*
09-xxx	Chemistry
33-xxx	Physics

* Those interested in a cognitive neuroscience focus are recommended to take biology courses, including if possible, 03-362, or 03-363.

Additional Major in Cognitive Science

In order to complete a double major in Cognitive Science, a student must fulfill the major requirements as listed under the Cognitive Science major. These include the programming requirement (15-112), the Mathematics and Statistics prerequisites, Computational/Cognitive Modeling Core, The Cognitive Psychology Core, the Cognitive Science Concentration Requirement, and the Supplementary Science Requirement. Students will

be assigned a department advisor to help plan their program of studies in Cognitive Science.

Minors in Psychology and Cognitive Neuroscience

72 units Minor in Psychology

I. Introductory course

85-102	Introduction to Psychology*	9
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*A survey course can be taken in place of 85-102.

II. Area Survey courses

Complete two courses.

85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	
85-219	Biological Foundations of Behavior	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9

III. Statistics

36-201	Statistical Reasoning and Practice	9
36-309	Experimental Design for Behavioral and Social Sciences	9

27 units Upper Level Courses

Complete three courses from categories IV and V, with at least one course from each.

IV. Research Methods Courses* (minimum 9 units)

85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	9
85-330	Analytic Research Methods	9
85-340	Research Methods in Social Psychology	9

* Prerequisites for all Research Methods courses: 36-309 and the appropriate survey course.

V. Advanced courses (minimum 9 units)

Advanced psychology courses exist within four areas (cognitive, cognitive neuroscience, developmental, social and health psychology.) Any advanced content course or seminar in psychology or any psychology course higher than 85-350. Exceptions for the advanced course requirement are: 85-480, 85-482, 85-484, 85-484, 85-506, 85-507, 85-508, 85-601, 85-602, 66-501, 66-502.

Minor in Cognitive Neuroscience 63 units

The minor in Cognitive Neuroscience offered by the Department of Psychology is similar to the Neuroscience Minor offered by the Department of Biological Sciences. The differences between the two forms of the minor are determined by one required course, and additionally, by the students' choice of distribution electives. The requirements for the Cognitive Neuroscience Minor include 7 courses: four required courses, and three distribution and elective courses.

Because of the curriculum within this minor may overlap with some degree requirements, no more than 2 courses fulfilling Neuroscience or Cognitive Neuroscience Minor requirements may count towards a student's major or other minor requirements.

Cognitive Neuroscience Curriculum

Required Coursework

03-121	Modern Biology	9
03-363	Systems Neuroscience	9
85-219	Biological Foundations of Behavior	9
85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	

Distribution Requirements

Three courses, including at least 1 from each of the following categories

Approaches to Cognitive Neuroscience		
85-314	Cognitive Neuroscience Research Methods	9
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing	9
85-429	Cognitive Brain Imaging	9
15-386	Neural Computation	9
15-883	Computational Models of Neural Systems	12
36-746	Statistical Methods for Neuroscience and Psychology	12
Cognitive Neuroscience Electives		
03-260	Neurobiology of Disease	9
03-362	Cellular Neuroscience	9
03-364	Developmental Neuroscience	9
03-761	Neural Plasticity	9
15-486	Artificial Neural Networks	12
85-356	Music and Mind: The Cognitive Neuroscience of Sound	9
85-370	Perception	9
85-385	Auditory Perception: Sense of Sound	9
85-390	Human Memory	9
85-406	Autism: Psychological and Neuroscience Perspectives	9

The Honors Program

The Honors Program provides recognition of outstanding performance by students in the Psychology department. Participation enables students to pursue their own research ideas through completion of an honors thesis. The honors thesis is completed during the senior year. By completing a thesis, the student earns 18 units of credit and qualifies for graduation with "College Honors." To qualify for the Honors Program, the student must maintain a quality point average of at least 3.50 in the major and 3.25 overall. More information on the Honor program can be found here (<http://www.cmu.edu/dietrich/undergraduate/programs/shp>).

A year long departmental senior thesis course exists (66-501 and 66-502) for students interested in pursuing a sizable research project who do not qualify for the honors program. More information can be obtained by contacting Emilie O'Leary at emilier@andrew.cmu.edu.

Faculty

JOHN R. ANDERSON, Richard King Mellon University Professor of Psychology and Computer Science - Ph.D., Stanford University; Carnegie Mellon, 1978-.

MARLENE BEHRMANN, Professor of Psychology - Ph.D., University of Toronto; Carnegie Mellon, 1993-.

SHARON CARVER, Director of Children's School, Teaching Professor of Psychology - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1993-.

SHELDON COHEN, Robert E. Doherty Professor of Psychology - Ph.D., New York University; Carnegie Mellon, 1982-.

CHANTE COX-BOYD, Associate Teaching Professor - Ph.D., University of North Carolina at Chapel Hill; Carnegie Mellon, 2001-.

DAVID CRESWELL, Associate Professor - Ph.D., University of California, Los Angeles; Carnegie Mellon, 2008-.

KASEY CRESWELL, Assistant Professor - Ph.D., University of Pittsburgh; Carnegie Mellon, 2012-.

BROOKE C. FEENEY, Professor of Psychology - Ph.D., State University of New York at Buffalo; Carnegie Mellon, 2001-.

ANNA FISHER, Associate Professor - Ph.D., The Ohio State University; Carnegie Mellon, 2006-.

JOHN R. HAYES, Emeritus Professor of Psychology - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1965-.

VICKI S. HELGESON, Professor of Psychology - Ph.D., University of Denver; Carnegie Mellon, 1990-.

LAURIE HELLER, Associate Teaching Professor - Ph.D., University of Pennsylvania; Carnegie Mellon, 2009-.

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MARCEL A. JUST, D. O. Hebb Professor of Psychology - Ph.D., Stanford University; Carnegie Mellon, 1972-.

CHARLES KEMP, Associate Professor - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2008-.

DAVID KLAHR, Walter van Dyke Bingham Professor - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1969-.

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KENNETH KOTOVSKY, Professor of Psychology, Director, Undergraduate Studies in Psychology - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1988-.

MARSHA C. LOVETT, Teaching Professor - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2000-.

BRIAN MACWHINNEY, Professor of Psychology - Ph.D., University of California, Berkeley; Carnegie Mellon, 1981-.

DAVID PLAUT, Professor of Psychology - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1994-.

DAVID RAKISON, Associate Professor - D.Phil., University of Sussex; Carnegie Mellon, 2000-.

LYNNE M. REDER, Professor of Psychology - Ph.D., University of Michigan; Carnegie Mellon, 1978-.

MICHAEL F. SCHEIER, Professor of Psychology, Head, Psychology Department - Ph.D., University of Texas; Carnegie Mellon, 1975-.

ROBERT S. SIEGLER, Theresa Heinz Professor of Psychology - Ph.D., State University of New York, Stony Brook; Carnegie Mellon, 1974-.

JAMES J. STASZEWSKI, Research Professor - Ph.D., Cornell University; Carnegie Mellon, 1995-.

MICHAEL TARR, Professor of Psychology - Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2009-.

ERIK D. THIESSEN, Associate Professor - Ph.D., University of Wisconsin, Madison; Carnegie Mellon, 2004-.

TIMOTHY VERSTYNEN, Assistant Professor - Ph.D., University of California, Berkeley; Carnegie Mellon, 2006-.

Department of Social and Decision Sciences

Department Office: Porter Hall 208
<http://www.cmu.edu/dietrich/sds/>

The Department of Social and Decision Sciences is a multidisciplinary department that offers undergraduate programs that seamlessly combine frontier knowledge in the social sciences with the practical skills needed to excel in key decision making roles in the public, private, and non-profit sectors and in advanced graduate studies. Our students learn how to combine intellectual ideals with the realities of human and organizational behavior and to apply these lessons across a wide variety of endeavors, ranging from government service to leadership positions in the information economy.

The department offers undergraduate majors in Decision Science and in Policy and Management. The core courses leverage our strength in decision analysis, empirical research, organizations, and policy analysis. In addition to completing this core, students also specialize in their major area through a set of required and elective courses.

Our faculty is committed to the academic success and growth of our students and many of our undergraduates work with faculty on research projects and internships. The directors of the majors are easily accessible and encourage students to talk with them about their curriculum, progress, and available opportunities.

The Department of Social and Decision Sciences has a long history of creating innovative and prescient undergraduate programs that combine key ideas from across the social sciences into cohesive majors that allow our graduates to excel in their chosen professions or in the pursuit of advanced studies. Our emphasis on the theory and practice of individual and social decision making linked with our high-quality, multidisciplinary social science faculty, provides a solid foundation from which graduates can embrace a variety of future paths.

The Major in Decision Science

Baruch Fischhoff, Faculty Director
 Office: Porter Hall 219E
 Connie Angermeier, Academic Advisor
 Office: Porter Hall 208A
 Email: cla2@andrew.cmu.edu

The interdisciplinary field of Decision Science seeks to understand and improve the judgment and decision making of individuals, groups, and organizations. Qualified graduates can continue to PhD programs in Decision Science or related fields (e.g., psychology, business), pursue professional degrees (e.g., MBA, MD, JD, MPH), or take professional positions in business, government, consulting, or the non-profit sector. Students work with faculty and the Academic Advisor to tailor their education to their personal needs and interest.

Carnegie Mellon is one of the leading centers for the study of Decision Science - and offers the only undergraduate major that integrates analytical and behavioral approaches to decision making. Our faculty are involved in applying Decision Science in a wide variety of areas, allowing them to share practical experiences with students. These applications include medical decision making (e.g., conveying the costs and benefits of treatment options), legal decision making (e.g., reducing the effects of hindsight bias on attributions of responsibility for accidents), risk management (e.g., assessing and communicating the risks of climate change), marketing (e.g., understanding the effects of inter-temporal choice on purchasing decisions), and business (e.g., identifying unrecognized conflicts of interest).

Decision Science is grounded in theories and methods drawn from psychology, economics, philosophy, statistics, and management science. Courses in the major cover the three aspects of decision science: (a) normative analysis, creating formal models of choice; (b) descriptive research, studying how cognitive, emotional, social, and institutional factors affect judgment and choice, and (c) prescriptive interventions, seeking to improve judgment and decision making. In addition to gaining a broad education in the principles of judgment and decision making, Decision Science majors gain broadly applicable skills in research design and analysis. They also have the chance to think about and discuss decision making in many different areas.

The core courses present fundamental theories and results from the study of decision making, along with their application to real-world problems. They introduce students to methods for collecting and analyzing behavioral data. For example, students learn to conduct surveys (e.g., uncovering consumer or managerial preferences), design experiments (e.g., evaluating theories,

comparing ways of presenting information), and evaluate the effectiveness of interventions.

The elective courses provide students with additional knowledge in areas of decision making that meet their personal, intellectual, and career goals. These courses are organized into six clusters: biological and behavioral aspects of decision making, managerial and organizational aspects, philosophical and ethical perspectives, economic and statistical methods, public policy, and research methods. Students can concentrate in one area or spread their studies across them. In addition to coursework, the department offers research opportunities for interested and qualified students. Participating in research helps students to extend their mastery of decision science, discover whether a research career is right for them, and get to know faculty and graduate students better.

Prerequisites

All Decision Science majors must complete mathematics, statistics, and analytic methods prerequisites (see below), by the end of the sophomore year.

Mathematics Prerequisite	Units
21-111-21-112 Calculus I-II or 21-120 Differential and Integral Calculus	10-20

Students who successfully pass the proctored Calculus Assessment on campus or who receive credit through accepted standardized exams (such as AP, IB, or Cambridge) at the 21-120 or 21-122 levels will be required to take a more advanced 21-xxx course for this prerequisite. 21-122, 21-240, or 21-256 are suggested.

Statistics Prerequisite	Units
36-201 Statistical Reasoning and Practice	9

Students must take one course from the following set (or an approved alternative). Students may not count a course used to fulfill the Mathematics Prerequisite as also filling the Analytic Methods Prerequisite.

Analytic Methods Prerequisite	Units
21-122 Integration and Approximation	10
21-256 Multivariate Analysis	9
21-257 Models and Methods for Optimization	9
36-309 Experimental Design for Behavioral and Social Sciences	9
36-401 Modern Regression	9
36-410 Introduction to Probability Modeling	9
80-211 Logic and Mathematical Inquiry	9
80-212 Arguments and Logical Analysis	9
88-252 Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9

Curriculum

The core curriculum in Decision Science consists of two courses in empirical research methods and five courses providing the theoretical perspectives of Decision Science.

Theoretical Perspectives	Units
88-120 Reason, Passion and Cognition **	9
85-211 Cognitive Psychology	9
88-220 Policy Analysis I	9
88-223 Decision Analysis and Decision Support Systems	9
88-302 Behavioral Decision Making	9
	45

** 88-120 should be taken in the freshman or sophomore year.

Research Methods	Units
36-202 Statistical Methods	9
88-251 Empirical Research Methods	9

18

Electives 45 units

Complete at least 45 units of courses from the following categories. The selected courses may be from one category or from any combination. Note that not all elective courses are offered every year.

At least three of these courses (27 units) must be Department of Social and Decision Sciences courses (88-xxx).

1. Biological and Behavioral Aspects of Decision Making		Units
85-352	Evolutionary Psychology	9
85-377	Attitudes and Persuasion	9
85-442	Health Psychology	9
88-342	The Neuroscience of Decision Making	9
88-360	Behavioral Economics	9
88-365	Behavioral Economics and Public Policy	9
88-388	Psychological Models of Decision Making	9
2. Managerial and Organization Aspects of Decision Making		
70-311	Organizational Behavior*	9
70-381	Marketing I	9
70-460	Mathematical Models for Consulting	9
88-221	Policy Analysis II	9
88-260	Organizations*	9
88-419	Negotiation	9
88-444	Public Policy and Regulation	9
88-451	Policy Analysis Senior Project	12
or 88-452	Policy Analysis Senior Project	
3. Philosophical and Ethical Perspectives on Decision Making		Units
19-426	Environmental Decision Making	9
80-208	Critical Thinking	9
80-221	Philosophy of Social Science	9
80-245	Medical Ethics	9
80-305	Rational Choice	9
80-321	Causation, Law, and Social Policy	9
4. Economic and Statistical Methods for Decision Science		Units
70-460	Mathematical Models for Consulting	9
73-347	Game Theory for Economists	9
80-337	Philosophy, Politics & Economics	9
80-405	Game Theory*	9
88-316	Game Theory*	9
88-360	Behavioral Economics	9
88-367	Behavioral Economics in the Wild	9
5. Decision Science and Public Policy		
84-393	Legislative Decision Making: U.S. Congress	9
88-221	Policy Analysis II	9
88-365	Behavioral Economics and Public Policy	9
88-405	Risk Perception and Communication	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
88-444	Public Policy and Regulation	9
88-451	Policy Analysis Senior Project	12
or 88-452	Policy Analysis Senior Project	
6. Research Methods for Decision Science		Units
36-303	Sampling, Survey and Society	9
70-460	Mathematical Models for Consulting	9
88-252	Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9
88-388	Psychological Models of Decision Making	9
88-402	Modeling Complex Social Systems	9
88-435	Decision Science and Policy	9

Note: Some courses have additional prerequisites.

Decision Science, B.S. Sample Curriculum

Freshman or Sophomore Year		Junior	
Fall	Spring	Fall	Spring
88-120 Reason, Passion and Cognition	36-202 Statistical Methods	88-220 Policy Analysis I	88-223 Decision Analysis and Decision Support Systems
General Education course	85-211 Cognitive Psychology	88-251 Empirical Research Methods	Decision Science Elective
General Education course	Prerequisite	88-302 Behavioral Decision Making	Elective
General Education course	General Education course	Elective	Elective
General Education course	General Education course	Elective	

Senior

Fall	Spring
Decision Science Elective	Decision Science Elective
Decision Science Elective	Decision Science Elective
Elective or Honors Thesis	Elective or Honors Thesis
Elective	Elective
Elective	Elective

This is presented as a recommended plan for completing major requirements. The major can be completed in as few as two years (not that it must be), but students may not have time for other opportunities such as additional majors or study abroad. Students may declare their major as early as after spring break in the freshman year. Students who are planning to study abroad or to apply for the Heinz Accelerated Masters Program may have a very different curriculum map and should consult early - and often - with the Decision Science Academic Advisor.

Students are encouraged to consider the Washington Semester Program as part of their education. Suitable courses will be considered as fulfilling requirements of electives in the major. Please send the course syllabus, along with a note explaining how the course addresses fundamental aspects of decision science in one of the six elective categories.

88-120 should be taken as the first course in the Decision Science sequence. It is intended for students in their first or second year; it is offered in Fall semesters. It may be taken as late as the junior year.

Additional Major in Decision Science

Students who elect Decision Science as an additional major must fulfill all of the requirements of the Decision Science major.

Students pursuing Policy and Management with an additional major in Decision Science and may only count 36-202, 88-220, 88-223, and 88-251 toward the completion of both majors.

Additional majors cannot count menu electives toward simultaneously fulfilling more than one major or minor. Students who are interested in an additional major in Decision Science should see the Academic Advisor of the Decision Science program.

The Major in Policy and Management

Paul Fischbeck, Director
Office: Porter Hall 208F
Connie Angermeier, Academic Advisor
Office: Porter Hall 208A
Email: cla2@andrew.cmu.edu

The Policy and Management major prepares students for key decision-making and management roles in government, non-profit organizations, and business. The major emphasizes analytic approaches to decision making and practical management skills necessary for graduates to excel in both the public and private sectors. The multidisciplinary curriculum merges frontier knowledge on both the ideals of decision making, policy, and organization, as well as the realities of individual and organizational behavior that must be confronted if high-quality outcomes are going to be attained.

The major is comprised of four clusters of courses. The Analytic Methods requirement consists of four courses that provide theoretical training and practical experience in problem solving and decision making. These courses provide systematic methods for dealing with the complexities that make decisions difficult, ranging from incorporating issues of risk and uncertainty in decision making to dealing with choices that have mutually conflicting objectives. For example, a business or government agency may need to decide on a policy for mitigating the uncertain impacts of air

pollution while simultaneously trying to minimize the costs of such a policy on manufacturing. A firm might want to consider the uncertain reductions in security dangers from alternative policies to protect against terrorism. In this requirement, students will gain an appreciation of the economic analysis of complex decisions, as well as the trade-off between economic and political-based decision making.

The Organizational Context requirement is a course that emphasizes the analysis of how people organize and coordinate their behavior to perform complex tasks that are beyond the capability of any single individual. The course uses a multidisciplinary approach to analyze the potential shortcomings of large organizations, such as inertia, group-think, coordination failure, and bureaucratic infighting.

The Research Methods requirement is comprised of two courses focused on key methods for collecting and analyzing data that are needed to make informed decisions. Students learn to use interviews, surveys, experiments, and econometric methods to enhance their ability to test existing, and design new, policies.

Finally, the Electives requirement consists of five courses chosen by the student, in coordination with the Academic Advisor, to add depth and breadth to the major. These courses are chosen from five categories that emphasize different aspects of decision making and management: (1) policy making, (2) management, (3) technology and information, (4) international policy, and (5) political science and law. The selected courses may be from one category or from any combination of categories.

The Policy and Management major provides an excellent combination of theoretical and practical skills for students who intend to seek managerial positions. Because of its strong analytic orientation, it is also an excellent major for those who intend to go on to professional school programs in law, business, or public policy. It is also an appropriate choice for students pursuing graduate degrees in economics, political science, or decision science. One such graduate option is the accelerated masters program offered by the H. J. Heinz III School of Public Policy and Management, in which a student earns both a B.S. in Policy and Management and a M.S. in Public Policy and Management in five years.

Prerequisites

All Policy and Management majors must complete mathematics and statistics prerequisites (see below), by the end of the sophomore year.

Mathematics Prerequisites	Units
21-111-21-112 Calculus I-II	10-20
or 21-120 Differential and Integral Calculus	
21-122 Integration and Approximation	10
or 21-256 Multivariate Analysis	

Students who successfully pass the proctored Calculus Assessment on campus or who receive credit through accepted standardized exams (such as AP, IB, or Cambridge) at the 21-122 level will be required to take a more advanced 21-xxx course for this prerequisite. 21-240 or 21-256 are suggested.

Statistics Prerequisite	Units
36-201 Statistical Reasoning and Practice	9

Curriculum

Analytical Methods	Units
88-220 Policy Analysis I	9
88-221 Policy Analysis II	9
88-223 Decision Analysis and Decision Support Systems	9
88-451 Policy Analysis Senior Project	12
or 88-452 Policy Analysis Senior Project	
	39

Organizational Context	Units
88-260 Organizations	9
	9

Research Methods	Units
36-202 Statistical Methods	9
88-251 Empirical Research Methods	9
	18

Electives 45 units

Complete at least 45 units (a minimum of five courses) from the following categories of courses. Most courses listed below are 9-unit courses, but some are less. When courses offered for less than 9 units are chosen,

students should note that a minimum of 45 units is required, and should plan to take one or more additional courses as appropriate. The categories were created only to help in your selection process. You may select courses from one category or from any combination of categories.

At least 27 units (a minimum of three courses) must be Social and Decision Sciences courses (88-xxx).

1. Policy Making	Units
36-303 Sampling, Survey and Society	9
73-328 Health Economics	12
73-331 Political Economy of Inequality and Redistribution	9
73-352 Public Economics	9
79-374 American Environmental History: Critical Issues	9
80-321 Causation, Law, and Social Policy	9
88-352 Environmental Economics and Policy	9
88-365 Behavioral Economics and Public Policy	9
88-412 Energy, Climate Change, and Economic Growth in the 21st Century	9
88-423 Institutions, Entrepreneurship, and Innovation	9
88-432 International Policy Decision Modeling Workshop	9
88-435 Decision Science and Policy	9
2. Management	Units
70-321 Negotiation and Conflict Resolution	9
70-332 Business, Society and Ethics	9
70-342 Managing Across Cultures	9
70-430 International Management	9
80-241 Ethical Judgments in Professional Life	9
80-244 Environmental Ethics	9
80-344 Management, Environment, and Ethics	9
88-252 Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9
88-341 Organizational Communication	9
88-360 Behavioral Economics	9
88-363 Behavioral Economics Theory	9
88-367 Behavioral Economics in the Wild	9
88-387 Social Norms and Economics	9
88-402 Modeling Complex Social Systems	9
88-403 Network and Social Systems	9
88-419 Negotiation	9
3. Technology and Information	Units
19-402 Telecommunications Technology, Policy & Management	12
19-448 Science, Technology & Ethics	9
73-474 The Economics of Ideas: Growth, Innovation and Intellectual Property	9
79-342 Introduction to Science and Technology Studies	9
80-341 Computers, Society and Ethics	9
88-345 Perspectives on Industrial Research and Development	9
88-347 Complex Technological Systems: Past, Present, and Future	9
88-371 Entrepreneurship, Regulation and Technological Change	9
88-391 Technology and Economic Growth	9
88-413 Energy and Climate: History, Science, Technology, & Policy in the US 1776-2076	9
88-415 Global Competitiveness: Firms Nations, and Technological Change	9
4. International Policy	Units
79-278 Rights to Representation: Indigenous People and their Media	9
80-247 Ethics and Global Economics	9
80-447 Global Justice	9
84-362 Diplomacy and Statecraft	9
84-389 Terrorism and Insurgency	9
84-414 International and Subnational Security	9
88-384 Conflict and Conflict Resolution in International Relations	9
88-410 The Global Economy: A User's Guide	9

88-411	Rise of the Asian Economies	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
88-432	International Policy Decision Modeling Workshop	9
5. Political Science and Law		Units
70-364	Business Law	9
70-365	International Trade and International Law	9
73-408	Law and Economics	9
80-235	Political Philosophy	9
80-321	Causation, Law, and Social Policy	9
84-393	Legislative Decision Making: U.S. Congress	9
84-402	Judicial Politics and Behavior	9
88-281	Topics in Law: 1st Amendment *	9
or 88-284	Topics of Law: The Bill of Rights	
88-444	Public Policy and Regulation	9

* only one course (either 88-281 or 88-284) may count toward an elective requirement in the Policy and Management major.

NOTE: Some courses have additional prerequisites.

Policy and Management, B.S. Sample Curriculum

Freshman or Sophomore Year		Junior Year
Spring	Fall	Spring
36-202 Statistical Methods	88-220 Policy Analysis I	88-221 Policy Analysis II
Open Prerequisite	88-251 Empirical Research Methods	88-223 Decision Analysis and Decision Support Systems
Open Prerequisite	Elective	88-260 Organizations
Elective	Elective	Elective
Elective	Elective	Elective

Senior Year	
Fall	Spring
88-452 Policy Analysis Senior Project or P&M elective	88-451 Policy Analysis Senior Project or P&M elective
Policy and Management Elective	Policy and Management Elective
Policy and Management Elective	Policy and Management Elective
Elective	Elective
Elective	Elective

This is presented as a two-year (junior-senior) plan for completing major requirements. Its purpose is to show that this program can be completed in as few as two years; not that it must be. Students may declare their major as early as after spring break of the first year. Students who are planning to study abroad or to apply for the Heinz Accelerated Masters Program may have a very different curriculum map and should consult early - and often - with the Academic Advisor.

Students are encouraged to consider the Washington Semester Program as part of their education. Suitable courses will be considered as fulfilling requirements of electives in the major. Please discuss course selections with the Academic Advisor after acceptance to the program.

Additional Major

Students who elect Policy and Management as an additional major must fulfill all of the requirements of the Policy and Management major.

Students pursuing Decision Science with an additional major in Policy and Management may only count 36-202 , 88-220 , 88-223 , and 88-251 toward the completion of both majors.

Additional majors cannot count menu electives toward simultaneously fulfilling more than one major or minor. Students who are interested in an additional major in Policy and Management should see the Academic Advisor of the Policy and Management program.

The Minor in Policy and Management

Paul Fischbeck, Faculty Director
 Office: Porter Hall 208F
 Connie Angermeier, Academic Advisor
 Office: Porter Hall 208A
 Email: cla2@andrew.cmu.edu

Regardless of major, many Carnegie Mellon graduates will face managerial challenges and responsibilities in their professional lives. Whether these are in their area of expertise or in more general settings, these roles will to some degree require assumption of the responsibility for directing the work of others. The Policy and Management minor is intended for students who expect to need these management concepts and skills. At most, one course may be double-counted with another major or minor.

Curriculum 54 units

36 units Required Courses

88-220	Policy Analysis I	9
88-221	Policy Analysis II	9
88-223	Decision Analysis and Decision Support Systems	9
88-260	Organizations	9

18 units Electives

Complete two courses from the following categories. At least one of the courses (9 units) must be a Social and Decision Sciences course (88-xxx).

1. Policy Making		Units
36-303	Sampling, Survey and Society	9
73-328	Health Economics	12
73-331	Political Economy of Inequality and Redistribution	9
73-352	Public Economics	9
79-374	American Environmental History: Critical Issues	9
80-321	Causation, Law, and Social Policy	9
88-352	Environmental Economics and Policy	9
88-365	Behavioral Economics and Public Policy	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
88-423	Institutions, Entrepreneurship, and Innovation	9
88-432	International Policy Decision Modeling Workshop	9
88-435	Decision Science and Policy	9
2. Management		Units
70-321	Negotiation and Conflict Resolution	9
70-332	Business, Society and Ethics	9
70-342	Managing Across Cultures	9
70-430	International Management	9
80-241	Ethical Judgments in Professional Life	9
80-244	Environmental Ethics	9
80-344	Management, Environment, and Ethics	9
88-252	Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More	9
88-341	Organizational Communication	9
88-360	Behavioral Economics	9
88-363	Behavioral Economics Theory	9
88-367	Behavioral Economics in the Wild	9
88-387	Social Norms and Economics	9
88-402	Modeling Complex Social Systems	9
88-403	Network and Social Systems	9
88-419	Negotiation	9
3. Technology and Information		Units
19-402	Telecommunications Technology, Policy & Management	12
19-448	Science, Technology & Ethics	9
73-474	The Economics of Ideas: Growth, Innovation and Intellectual Property	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-342	Introduction to Science and Technology Studies	9
80-341	Computers, Society and Ethics	9
88-345	Perspectives on Industrial Research and Development	9

88-347	Complex Technological Systems: Past, Present, and Future	9
88-371	Entrepreneurship, Regulation and Technological Change	9
88-391	Technology and Economic Growth	9
88-413	Energy and Climate: History, Science, Technology, & Policy in the US 1776-2076	9
88-415	Global Competitiveness: Firms Nations, and Technological Change	9
4. International Policy		Units
79-278	Rights to Representation: Indigenous People and their Media	9
80-247	Ethics and Global Economics	9
80-447	Global Justice	9
84-389	Terrorism and Insurgency	9
84-414	International and Subnational Security	9
88-384	Conflict and Conflict Resolution in International Relations	9
88-410	The Global Economy: A User's Guide	9
88-411	Rise of the Asian Economies	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9
88-432	International Policy Decision Modeling Workshop	9
5. Political Science and Law		Units
70-364	Business Law	9
70-365	International Trade and International Law	9
73-408	Law and Economics	9
80-235	Political Philosophy	9
80-321	Causation, Law, and Social Policy	9
84-393	Legislative Decision Making: U.S. Congress	9
84-402	Judicial Politics and Behavior	9
88-281	Topics in Law: 1st Amendment *	9
or 88-284	Topics of Law: The Bill of Rights	
88-444	Public Policy and Regulation	9

* only one course (either 88-281 or 88-284) may count toward an elective requirement in the Policy and Management minor.

NOTE: Some courses have additional prerequisites.

Faculty

LINDA BABCOCK, James Mellon Walton Professor of Economics and Department Head - Ph.D., University of Wisconsin-Madison; Carnegie Mellon, 1988-.

SAURABH BHARGAVA, Assistant Professor - Ph.D., University of California, Berkeley; Carnegie Mellon, 2012-.

SERGUEY BRAGUINSKY, Associate Professor - Ph.D., Keio University, Japan; Carnegie Mellon, 2008-.

LEE BRANSTETTER, Professor - Ph.D., Harvard University; Carnegie Mellon, 2006-.

STEPHEN BROOMELL, Assistant Professor - Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2011-.

JULIE DOWNS, Associate Professor - Ph.D., Princeton University; Carnegie Mellon, 1995-.

PAUL S. FISCHBECK, Professor of Social and Decision Sciences and Engineering and Public Policy - Ph.D., Stanford University; Carnegie Mellon, 1990-.

BARUCH FISCHHOFF, Howard Heinz University Professor of Social and Decision Sciences and of Engineering and Public Policy - Ph.D., The Hebrew University of Jerusalem; Carnegie Mellon, 1987-.

CHRISTINA FONG, Senior Research Scientist - Ph.D., University of Massachusetts, Amherst; Carnegie Mellon, 2001-.

RUSSELL GOLMAN, Assistant Professor - Ph.D., The University of Michigan; Carnegie Mellon, 2010-.

CLEOTILDE GONZALEZ, Research Professor of Information and Decision Sciences - Ph.D., Texas Tech University; Carnegie Mellon, 2000-.

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ALEX IMAS, Assistant Professor - Ph.D., University of California, San Diego; Carnegie Mellon, 2014-.

MARK S. KAMLET, University Professor of Economics and Public Policy and Provost Emeritus - Ph.D., University of California, Berkeley; Carnegie Mellon, 1978-.

GEORGE F. LOEWENSTEIN, Herbert A. Simon University Professor of Economics and Psychology - Ph.D., Yale University; Carnegie Mellon, 1990-.

JOHN H. MILLER, Professor of Economics and Social Science - Ph.D., The University of Michigan; Carnegie Mellon, 1989-.

Faculty by Courtesy Appointment

LINDA ARGOTE, David and Barbara Kirr Professor of Organizational Behavior - Ph.D., University of Michigan; Carnegie Mellon, 1979-.

KATHLEEN M. CARLEY, Professor of Sociology - Ph.D., Harvard University; Carnegie Mellon, 1984-.

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JEFFREY GALAK, Associate Professor of Marketing - Ph.D., New York University; Carnegie Mellon, 2009-.

JOSEPH B. KADANE, Leonard J. Savage University Professor of Statistics and Social Science - Ph.D., Stanford University; Carnegie Mellon, 1969-.

SARAH B. KIESLER, Professor - Ph.D., The Ohio State University; Carnegie Mellon, 1979-.

DAVID M. KRACKHARDT, Professor of Organizations and Public Policy - Ph.D., University of California, Irvine; Carnegie Mellon, 1991-.

ROBERT E. KRAUT, Hebert A. Simon Professor of Human Computer Interaction - Ph.D., Yale University; Carnegie Mellon, 1993-.

KIRON K. SKINNER, Associate Professor of International Relations and Political Science - Ph.D., Harvard University; Carnegie Mellon, 1999-.

JOEL TARR, Richard S. Caliguiri University Professor of History and Policy - Ph.D., Northwestern University; Carnegie Mellon, 1967-.

Emeritus Faculty

WILLIAM R. KEECH, Ph.D. University of Wisconsin-Madison; Carnegie Mellon, 1997-.

Department of Statistics

Chris Genovese, Department Head
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Uncertainty is inescapable: randomness, measurement error, deception, and incomplete or missing information complicate all our lives. Statistics is the science and art of making predictions and decisions in the face of uncertainty. Statistical issues are central to big questions in public policy, law, medicine, industry, computing, technology, finance, and science. Indeed, the tools of Statistics apply to problems in almost every area of human activity where data are collected.

Statisticians must master diverse skills in computing, mathematics, decision making, forecasting, interpretation of complicated data, and design of meaningful comparisons. Moreover, statisticians must learn to collaborate effectively with people in other fields and, in the process, to understand the substance of these other fields. For all these reasons, Statistics students are highly sought-after in the marketplace.

Recent Statistics majors at Carnegie Mellon have taken jobs at leading companies in many fields, including the National Economic Research Association, Boeing, Morgan Stanley, Deloitte, Rosetta Marketing Group, Nielsen, Proctor and Gamble, Accenture, and Goldman Sachs. Other students have taken research positions at the National Security Agency, the U.S. Census Bureau, and the Science and Technology Policy Institute or worked for Teach for America. Many of our students have also gone on to graduate study at some of the top programs in the country including Carnegie Mellon, the Wharton School at the University of Pennsylvania, Johns Hopkins, University of Michigan, Stanford University, Emory University, Yale University, Columbia University, and Georgia Tech.

The Department and Faculty

The Department of Statistics at Carnegie Mellon University is world-renowned for its contributions to statistical theory and practice. Research in the department runs the gamut from pure mathematics to the hottest frontiers of science. Current research projects are helping make fundamental advances in neuroscience, cosmology, seismology, finance, and genetics.

The faculty members are recognized around the world for their expertise and have garnered many prestigious awards and honors. (For example, three members of the faculty have been awarded the COPSS medal, the highest honor given by professional statistical societies.) At the same time, the faculty is firmly dedicated to undergraduate education. The entire faculty, junior and senior, teach courses at all levels. The faculty are accessible and are committed to involving undergraduates in research.

The Department augments all these strengths with a friendly, energetic working environment and exceptional computing resources. Talented graduate students join the department from around the world, and add a unique dimension to the department's intellectual life. Faculty, graduate students, and undergraduates interact regularly.

How to Take Part

There are many ways to get involved in Statistics at Carnegie Mellon:

- The Bachelor of Science in Statistics in the Dietrich College of Humanities and Social Sciences (DC) is a broad-based, flexible program that helps you master both the theory and practice of Statistics. The program can be tailored to prepare you for later graduate study in Statistics or to complement your interests in almost any field, including Psychology, Physics, Biology, History, Business, Information Systems, and Computer Science.
- The Minor (or Additional Major) in Statistics is a useful complement to a (primary) major in another Department or College. Almost every field of inquiry must grapple with statistical problems, and the tools of statistical theory and data analysis you will develop in the Statistics minor will give you a critical edge.
- The Bachelor of Science in Economics and Statistics provides an interdisciplinary course of study aimed at students with a strong interest in the empirical analysis of economic data. Jointly administered by the Department of Statistics and the Undergraduate Economics Program, the major's curriculum provides students with a solid foundation in the theories and methods of both fields. (See Dietrich College Interdepartmental Majors as well as later in this section)

- The Bachelor of Science in Statistics and Machine Learning is a program housed in the Department of Statistics in which students take courses focused on Machine Learning.
- The Statistical and Mathematical Sciences Program (within the Science and Humanities Scholars Program) is an alternative path for the study of Statistics that is jointly administered by the Department of Mathematical Sciences and the Department of Statistics.
- The Statistics Concentration and the OR and Statistics Concentration in the Mathematical Sciences Major (see Department of Mathematical Sciences) are jointly administered by the Department of Mathematical Sciences and the Department of Statistics.
- There are several ongoing exciting research projects in the Department of Statistics, and the department enthusiastically seeks to involve undergraduates in this work. Both majors and non-majors are welcome.
- Non-majors are eligible to take most of our courses, and indeed, they are required to do so by many programs on campus. Such courses offer one way to learn more about the Department of Statistics and the field in general.

Curriculum

Statistics consists of two intertwined threads of inquiry: Statistical Theory and Data Analysis. The former uses probability theory to build and analyze mathematical models of data in order to devise methods for making effective predictions and decisions in the face of uncertainty. The latter involves techniques for extracting insights from complicated data, designs for accurate measurement and comparison, and methods for checking the validity of theoretical assumptions. Statistical Theory informs Data Analysis and vice versa. The Statistics Department curriculum follows both of these threads and helps the student develop the complementary skills required.

Below, we describe the requirements for the Major in Statistics and the different categories within our basic curriculum, followed by the requirements for the Minor in Statistics and the requirements for the Major in Economics and Statistics.

Note: We recommend that you use the information provided below as a general guideline, and then schedule a meeting with a Statistics Undergraduate Advisor (email: acadcoord@stat.cmu.edu) to discuss the requirements in more detail, and build a program that is tailored to your strengths and interests.

B.S. in Statistics

Academic Advisor: Paige Houser
Faculty Advisor: Howard Seltman
Office: Baker Hall 132A
Email: acadcoord@stat.cmu.edu

Students in the Bachelor of Science program develop and master a wide array of skills in computing, mathematics, statistical theory, and the interpretation and display of complex data. In addition, Statistics majors gain experience in applying statistical tools to real problems in other fields and learn the nuances of interdisciplinary collaboration. The requirements for the Major in Statistics are detailed below and are organized by categories #1-#7.

1. Mathematical Foundations (Prerequisites)29–39 units

Mathematics is the language in which statistical models are described and analyzed, so some experience with basic calculus and linear algebra is an important component for anyone pursuing a program of study in Statistics.

Calculus*:

Complete one of the following three sequences of mathematics courses at Carnegie Mellon, each of which provides sufficient preparation in calculus:

Sequence 1

21-111	Calculus I	10
21-112	Calculus II	10

and one of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

Sequence 2

21-120	Differential and Integral Calculus	10
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and one of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

Note: Other sequences are possible, and require approval from the undergraduate advisor.

Note: Passing the MSC 21-120 assessment test is an acceptable alternative to completing 21-120.

Linear Algebra:**

Complete *one* of the following three courses:

21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	10
21-242	Matrix Theory	10

* It is recommended that students complete the calculus requirement during their freshman year.

**The linear algebra requirement needs to be completed before taking 36-401 Modern Regression.

21-241 and 21-242 are intended only for students with a very strong mathematical background.

2. Data Analysis:36-45 units

Data analysis is the art and science of extracting insight from data. The art lies in knowing which displays or techniques will reveal the most interesting features of a complicated data set. The science lies in understanding the various techniques and the assumptions on which they rely. Both aspects require practice to master.

The Beginning Data Analysis courses give a hands-on introduction to the art and science of data analysis. The courses cover similar topics but differ slightly in the examples they emphasize. 36-201 draws examples from many fields and satisfies the H&SS College Core Requirement in Statistical Reasoning. It is therefore the recommended course for students in the College. (Note: A score of 5 on the Advanced Placement (AP) Exam in Statistics may be used to waive this requirement). Other courses emphasize examples in business (36-207), engineering and architecture (36-220), and the laboratory sciences (36-247).

The Intermediate Data Analysis courses build on the principles and methods covered in the introductory course, and more fully explore specific types of data analysis methods in more depth.

The Advanced Data Analysis courses draw on students' previous experience with data analysis and understanding of statistical theory to develop advanced, more sophisticated methods. These core courses involve extensive analysis of real data with emphasis on developing the oral and writing skills needed for communicating results.

Sequence 1 (For students beginning their freshman or sophomore year)**Beginning***

Choose *one* of the following courses:

36-201	Statistical Reasoning and Practice	9
36/70-207	Probability and Statistics for Business Applications	9
36-220	Engineering Statistics and Quality Control	9
36-247	Statistics for Lab Sciences	9

*Or extra statistical elective

Note: Students who enter the program with 36-225 or 36-226 should discuss options with an advisor. Any 36-300 or 36-400 level course that does not satisfy any other requirement for a Statistics Major and Minor may be counted as a Statistical Elective.

Intermediate

Choose *one* of the following courses

36-202	Statistical Methods	9
36/70-208	Regression Analysis	9
36-309	Experimental Design for Behavioral and Social Sciences	9

*Or extra statistical elective

Advanced

Choose *one* of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9

Students can also take a second 36-46x (see section #5).

and take the following two courses:

36-401	Modern Regression	9
36-402	Advanced Methods for Data Analysis	9

Sequence 2 (For students beginning later in their college career)**Advanced**

Choose *two* of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9

and take the following two courses:

36-401	Modern Regression	9
36-402	Advanced Methods for Data Analysis	9

3. Probability Theory and Statistical Theory:18 units

The theory of probability gives a mathematical description of the randomness inherent in our observations. It is the language in which statistical models are stated, so an understanding of probability is essential for the study of statistical theory. Statistical theory provides a mathematical framework for making inferences about unknown quantities from data. The theory reduces statistical problems to their essential ingredients to help devise and evaluate inferential procedures. It provides a powerful and wide-ranging set of tools for dealing with uncertainty.

To satisfy the theory requirement take the following two courses:

36-225	Introduction to Probability Theory **	9
and one of the following two courses:		
36-226	Introduction to Statistical Inference	9
36-326	Mathematical Statistics (Honors)	9

**It is possible to substitute 36-217 or 21-325 for 36-225. (36-225 is the standard introduction to probability, 36-217 is tailored for engineers and computer scientists, and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.)

Comments:

(i) In order to be a Major or a Minor in good standing, a grade of at least a C is required in 36-225, 36-226 and 36-401. In particular, a grade of C or higher is required in order to be able to continue in the major.

(ii) In special cases, and in consultation with the Statistics Advisor, the theory requirement can be satisfied by taking the single *graduate level* class 36-625 Probability and Mathematical Statistics I, which is much more mathematically rigorous. This option should be considered by strong Statistics Majors who are also majoring in Computer Science, Operations Research, or Mathematics and/or who are considering graduate study in Statistics. This option does require special permission from the advisor. Students who end up satisfying the theory requirement by taking the (single) course 36-625 are required to take an additional statistics elective (see category #6, Statistical Electives, below).

4. Statistical Computing:9 units

36-350	Statistical Computing *	9
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*A higher level Computer Science course approved by your Statistics advisor may be used as a substitute.

5. Special Topics9 units

The Statistics Department offers advanced courses that focus on specific statistical applications or advanced statistical methods. These courses are numbered 36-46x (36-461, 36-462, etc.). Two of these courses will be offered every year, one per semester. Past topics included Statistical Learning, Data Mining, Statistics and the Law, Bayesian Statistics, Nonparametric Statistics, Statistical Genetics, Multilevel and Hierarchical Models, and Statistical Methods in Epidemiology. The objective of the course

is to expose students to important topics in statistics and/or interesting applications which are not part of the standard undergraduate curriculum.

To satisfy the Special Topics requirement choose *one* of the **36-46x** courses (which are 9 units).

Note: All 36-46x courses require 36-401 as a prerequisite or instructor permission.

6. Statistical Elective:9-10 units

Students are required to take one* elective which can be within or outside the Statistics Department. **Courses within statistics** can be any 300 or 400 level course (that is not used to satisfy any other requirement for the statistics major).

The following is a partial list of **courses outside statistics** that qualify as electives as they provide intellectual infrastructure that will advance the student's understanding of statistics and its applications. Other courses may qualify as well; consult with the Statistics Undergraduate Advisor.

15-110	Principles of Computing	10
15-121	Introduction to Data Structures	10
15-122	Principles of Imperative Computation	10
21-127	Concepts of Mathematics	10
21-260	Differential Equations	9
21-292	Operations Research I	9
21-301	Combinatorics	9
21-355	Principles of Real Analysis I	9
80-220	Philosophy of Science	9
80-221	Philosophy of Social Science	9
80-310	Formal Logic	9
85-310	Research Methods in Cognitive Psychology	9
85-320	Research Methods in Developmental Psychology	9
85-340	Research Methods in Social Psychology	9
88-223	Decision Analysis and Decision Support Systems	9
88-302	Behavioral Decision Making	9

Note: Additional prerequisites are required for some of these courses. Students should carefully check the course descriptions to determine if additional prerequisites are necessary.

* Students who enter the program through 36-225 or 36-226 and skip the beginning data analysis course, or students who end up satisfying the theory requirement using the (single) course 36-625, are required to take *two* electives only one of which can be outside the Statistics Department. (In general, any waived requirement is replaced by a statistical elective.)

7. Tracks*:

Self-Defined Concentration Area (with advisor's approval)36 units

The power of Statistics, and much of the fun, is that it can be applied to answer such a wide variety of questions in so many different fields. A critical part of statistical practice is understanding the questions being asked so that appropriate methods of analysis can be used. Hence, a critical part of statistical training is to gain experience applying the abstract tools to real problems. The Concentration Area is a set of four related courses outside of Statistics that prepares the student to deal with statistical aspects of problems that arise in another field. These courses are usually drawn from a *single* discipline of interest to the student and are chosen in consultation with the Statistics Undergraduate Advisor. For example, students intending to pursue careers in public policy could take further courses in History or Economics, students intending to pursue careers in the health or biomedical sciences could take further courses in Biology or Chemistry, and students intending to pursue graduate work in Statistics could take further courses in advanced Mathematics.

Mathematical Statistics Track46-52 units

21-127	Concepts of Mathematics	10
21-355	Principles of Real Analysis I	9
36-410	Introduction to Probability Modeling	9

And two of the following:

36-700	Probability and Mathematical Statistics I	12
36-705	Intermediate Statistics	12
21-228	Discrete Mathematics	9
21-257	Models and Methods for Optimization or	9
21-292	Operations Research I	9
21-301	Combinatorics	9

21-356	Principles of Real Analysis II	9
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Statistics and Neuroscience Track45-54 units

85-211	Cognitive Psychology	9
85-219	Biological Foundations of Behavior	9

And three electives (at least one from Methodology and Analysis and at least one from Neuroscientific Background):

Methodology and Analysis

36-625	Probability and Mathematical Statistics I	12
36-626	Probability and Mathematical Statistics II	12
10-601	Introduction to Machine Learning	12
18-290	Signals and Systems	12
85-314	Cognitive Neuroscience Research Methods	9
42/86-631	Neural Data Analysis	9

Neuroscientific Background

03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
15-386	Neural Computation	9
85-355	Introduction to Cognitive Neuroscience	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing	9

* Note: The concentration/track requirement is only for students whose *primary* major is statistics and have no other additional major or minor. The requirement does not apply for students who pursue an *additional* major in statistics.

Total Number of Units for the Major: 146-175*

Total Number of Units for the Degree: 360

* Note: This number can vary depending on the calculus sequence a student takes. In addition this number includes the 36 units of the "Concentration Area" category which may not be required (see category 6 above for details).

Recommendations

Students in the College of Humanities and Social Sciences who wish to major or minor in Statistics are advised to complete both the calculus requirement (one Mathematical Foundations calculus sequence) and the Beginning Data Analysis course 36-201 Statistical Reasoning and Practice by the end of their Freshman year.

The linear algebra requirement is a prerequisite for the course 36-401. It is therefore essential to complete this requirement during your junior year at the latest!

Recommendations for Prospective PhD Students

Students interested in pursuing a PhD in Statistics or Biostatistics (or related programs) after completing their undergraduate degree are strongly recommended to pursue the **Mathematical Statistics Track**.

Additional Major in Statistics

Students who elect Statistics as a second or third major must fulfill all Statistics degree requirements except for the Concentration Area requirement. Majors in many other programs would naturally complement a Statistics Major, including Tepper's undergraduate business program, Social and Decision Sciences, Policy and Management, and Psychology.

With respect to double-counting courses, it is departmental policy that students must have at least five statistics courses that do not count for their primary major. If students do not have at least five, they typically take additional advanced electives.

Students are advised to begin planning their curriculum (with appropriate advisors) as soon as possible. This is particularly true if the other major has a complex set of requirements and prerequisites or when many of the other major's requirements overlap with the requirements for a Major in Statistics.

Research

One goal of the Statistics program is to give students experience with statistical research. There is a wide variety of ongoing research projects in the department, and students have several opportunities to get involved in a project that interests them.

Before graduation, students are encouraged to participate in a research project under faculty supervision. Students can do this through projects in specific courses (such as 36-303), through an independent study, or through a summer research position.

Qualified students are also encouraged to participate in an advanced research project through 36-490 Undergraduate Research or independent study under the supervision of a Statistics faculty advisor. Students who maintain a quality point average of 3.25 overall may also apply to participate in the H&SS Senior Honors Program (p. 203).

Sample Programs

The following sample programs illustrate three (of many) ways to satisfy the requirements of the Statistics Major. However, keep in mind that the program is flexible enough to support *many* other possible schedules and to emphasize a wide variety of interests.

The first schedule uses calculus sequence 1, and 21-127 Concepts of Mathematics as a Statistical Elective outside of Statistics.

The second schedule is an example of the case when a student enters the program through 36-225 and 36-226 (and therefore skips the beginning data analysis course). The schedule uses calculus sequence 2, and includes two electives (36-315 and 36-410), both within the Statistics Department. This schedule has more emphasis on statistical theory and probability.

The third schedule is an example of the Mathematical Statistics track.

In these schedules, C.A. refers to Concentration Area courses.

Schedule 1

Freshman		Sophomore	
Fall	Spring	Fall	Spring
36-201 Statistical Reasoning and Practice	36-202 Statistical Methods	21-127 Concepts of Mathematics	36-315 Statistical Graphics and Visualization
21-111 Calculus I	21-112 Calculus II	21-256 Multivariate Analysis	C.A.

Junior		Senior	
Fall	Spring	Fall	Spring
36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference	36-401 Modern Regression	36-402 Advanced Methods for Data Analysis
21-240 Matrix Algebra with Applications	C.A.	C.A.	36-46x Special Topics
36-350 Statistical Computing			C.A.

Schedule 2

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference
			21-240 Matrix Algebra with Applications

Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-315 Statistical Graphics and Visualization	36-46x Special Topics	36-410 Introduction to Probability Modeling
36-401 Modern Regression	36-402 Advanced Methods for Data Analysis	C.A.	C.A.
C.A.	C.A.		

Schedule 3

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference
21-127 Concepts of Mathematics	21-260 Differential Equations		21-241 Matrices and Linear Transformations

Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-315 Statistical Graphics and Visualization	36-46x Special Topics	36-410 Introduction to Probability Modeling
36-401 Modern Regression	36-402 Advanced Methods for Data Analysis	21-355 Principles of Real Analysis I	
21-228 Discrete Mathematics	21-341 Linear Algebra		

B.S. in Economics and Statistics

Academic Advisor: Paige Houser

For questions about Economics courses contact: Carol Goldberg or Kathleen Conway

For questions about Statistics courses contact: Rebecca Nugent or Paige Houser

Office: Baker Hall 132A

Email: acadcoord@stat.cmu.edu

The Major in Economics and Statistics provides an interdisciplinary course of study aimed at students with a strong interest in the empirical analysis of economic data. With joint curriculum from the Department of Statistics and the Undergraduate Economics Program, the major provides students with a solid foundation in the theories and methods of both fields. Students in this major are trained to advance the understanding of economic issues through the analysis, synthesis and reporting of data using the advanced empirical research methods of statistics and econometrics. Graduates are well positioned for admission to competitive graduate programs, including those in statistics, economics and management, as well as for employment in positions requiring strong analytic and conceptual skills - especially those in economics, finance, education, and public policy.

The requirements for the B.S. in Economics and Statistics are the following:

I. Prerequisites

38-39 units

1. Mathematical Foundations

38-39 units

Calculus

21-120 Differential and Integral Calculus 10

and one of the following three:

21-122 Integration and Approximation 10

21-127 Concepts of Mathematics 10

21-257 Models and Methods for Optimization 9

and one of the following:

21-256 Multivariate Analysis 9

21-259 Calculus in Three Dimensions 9

Note: Passing the MSC 21-120 assessment test is an acceptable alternative to completing 21-120.

Note: Taking both 21-111 and 21-112 is equivalent to 21-120. The Mathematical Foundations total is then 48-49 units. The Economics and Statistics major would then total 201-202 units.

Linear Algebra

One of the following three courses:

21-240 Matrix Algebra with Applications 10

21-241 Matrices and Linear Transformations 10

21-242 Matrix Theory 10

Note: 21-241 and 21-242 are intended only for students with a very strong mathematical background.

II. Foundations

18-27 units

2. Economics Foundations

9 units

73-100 Principles of Economics 9

3. Statistical Foundations

9-18 units

Sequence 1 (For students beginning their freshman or sophomore year)

36-201 Statistical Reasoning and Practice 9

and one of the following:

36-202	Statistical Methods	9
36-208	Regression Analysis	9
36-309	Experimental Design for Behavioral and Social Sciences	9

Or extra statistical elective**

*Acceptable equivalents for 36-201 are 36-207 (70-207), 36-220 and 36-247.

**Students who enter the program with 36-225/36-226 should discuss options with their advisors.

Sequence 2 (For students beginning later in their college career)

Advanced

Choose one of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9

III. Disciplinary Core 126 units

1. Economics Core 36 units

73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
73-270	Writing for Economists	9
73-374	Econometrics II	9

2. Statistics Core 36 units

36-225	Introduction to Probability Theory *#	9
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and one of the following two courses:

36-226	Introduction to Statistical Inference *	9
36-326	Mathematical Statistics (Honors) *	9

and both of the following two courses:

36-401	Modern Regression *	9
36-402	Advanced Methods for Data Analysis	9

*In order to be a major in good standing, a grade of C or better is required in 36-225 (or equivalents), 36-226 or 36-326 and 36-401. Otherwise you will not be allowed to continue in the major.

#It is possible to substitute 36-217 or 21-325 for 36-225. (36-225 is the standard introduction to probability, 36-217 is tailored for engineers and computer scientists, and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.)

3. Computing 9 units

36-350	Statistical Computing *	9
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*A higher level Computer Science course approved by your Academic Advisor may be used as a substitute.

4. Advanced Electives 45 units

Students must take three advanced Economics elective courses (numbered 73-300 through 73-495, excluding 73-374, 73-407 and 73-450) and two advanced Statistics elective courses (numbered 36-303, 36-315, or 36-410 through 36-495).

Total number of units for the major 182-192 units

Total number of units for the degree 360 units

Sample Program

The following sample program illustrates one way to satisfy the requirements of the Economics and Statistics Major. Keep in mind that the

program is flexible and can support other possible schedules (see footnotes below the schedule).

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	36-202 Statistical Methods	21-122 Integration and Approximation **	21-240 Matrix Algebra with Applications
36-201 Statistical Reasoning and Practice	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
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Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-402 Advanced Methods for Data Analysis	Statistics Elective	Economics Elective
36-401 Modern Regression	73-270 Writing for Economists	Economics Elective	Statistics Elective
73-374 Econometrics II	Economics Elective	-----	-----
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*In each semester, ----- represents other courses (not related to the major) which are needed in order to complete the 360 units that the degree requires.

** Students can also take 21-127 or 21-257. Students should consult with their advisor.

73-155 is not required but it is recommended by the Economics department.

Prospective PhD students might add 21-127 fall of sophomore year, replace 21-240 with 21-241, add 21-260 in spring of junior year and 21-355 in fall of senior year.

Students who elect Economics and Statistics as a second major must fulfill all Economic and Statistics degree requirements. Majors in many other programs would naturally complement a Statistics Major, including Business Administration, Social and Decision Sciences, Policy and Management, Social & Political History, and Psychology.

With respect to double-counting courses, it is departmental policy that students must have at least six courses (three Economics and three Statistics) that do not count for their primary major. If students do not have at least six, they typically take additional advanced electives.

Students are advised to begin planning their curriculum (with appropriate advisors) as soon as possible. This is particularly true if the other major has a complex set of requirements and prerequisites.

B.S. in Statistics and Machine Learning

Academic Advisor: Paige Houser
 Faculty Advisor: Ryan Tibshirani
 Office: Baker Hall 132A
 Email: acadcoord@stat.cmu.edu

Students in the Bachelor of Science program develop and master a wide array of skills in computing, mathematics, statistical theory, and the interpretation and display of complex data. In addition, Statistics and Machine Learning majors gain experience in applying statistical tools to real problems in other fields and learn the nuances of interdisciplinary collaboration. This program is geared towards students interested in statistical computation, data science, or “Big Data” problems. The requirements for the Major in Statistics and Machine Learning are detailed below and are organized by categories.

1. Mathematical Foundations (Prerequisites) 49 - 59 units

Mathematics is the language in which statistical models are described and analyzed, so some experience with basic calculus and linear algebra is an important component for anyone pursuing a program of study in Statistics and Machine Learning.

Calculus*:

Complete one of the following three sequences of mathematics courses at Carnegie Mellon, each of which provides sufficient preparation in calculus:

Sequence 1

21-111 Calculus I

21-112	Calculus II	10
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and one of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

Sequence 2

21-120	Differential and Integral Calculus	10
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and one of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

Note: Other sequences are possible, and require approval from the undergraduate advisor.

Note: Passing the MSC 21-120 assessment test is an acceptable alternative to completing 21-120.

Integration and Approximation

21-122	Integration and Approximation	10
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Linear Algebra**:

Complete one of the following three courses:

21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	10
21-242	Matrix Theory	10

* It is recommended that students complete the calculus requirement during their freshman year.

**The linear algebra requirement needs to be completed before taking 36-401 Modern Regression.

21-241 and 21-242 are intended only for students with a very strong mathematical background.

Mathematical Theory:

21-127	Concepts of Mathematics	10
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2. Data Analysis 45 - 54 units

Data analysis is the art and science of extracting insight from data. The art lies in knowing which displays or techniques will reveal the most interesting features of a complicated data set. The science lies in understanding the various techniques and the assumptions on which they rely. Both aspects require practice to master.

The Beginning Data Analysis courses give a hands-on introduction to the art and science of data analysis. The courses cover similar topics but differ slightly in the examples they emphasize. 36-201 draws examples from many fields and satisfies the Dietrich College Core Requirement in Statistical Reasoning. It is therefore the recommended course for students in the College. (Note: A score of 4 or 5 on the Advanced Placement (AP) Exam in Statistics may be used to waive this requirement). Other courses emphasize examples in business (36-207), engineering and architecture (36-220), and the laboratory sciences (36-247).

The Intermediate Data Analysis courses build on the principles and methods covered in the introductory course, and more fully explore specific types of data analysis methods in more depth.

The Advanced Data Analysis courses draw on students' previous experience with data analysis and understanding of statistical theory to develop advanced, more sophisticated methods. These core courses involve extensive analysis of real data with emphasis on developing the oral and writing skills needed for communicating results.

Sequence 1

Beginning*

Choose one of the following courses:

36-201	Statistical Reasoning and Practice	9
36/70-207	Probability and Statistics for Business Applications	9
36-220	Engineering Statistics and Quality Control	9
36-247	Statistics for Lab Sciences	9

*Or extra statistical elective

Note: Students who enter the program with 36-225 or 36-226 should discuss options with an advisor. Any 36-300 or 36-400 level course that does

not satisfy any other requirement for a Statistics Major and Minor may be counted as a Statistical Elective.

Intermediate

Choose one of the following courses:

36-202	Statistical Methods	9
36/70-208	Regression Analysis	9
36-309	Experimental Design for Behavioral and Social Sciences	9

*Or extra statistical elective

Advanced

Choose two of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9

and take the following two courses:

36-401	Modern Regression	9
36-402	Advanced Methods for Data Analysis	9

Sequence 2

Advanced

Choose three of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9

and take the following two courses:

36-401	Modern Regression	9
36-402	Advanced Methods for Data Analysis	9

3. Probability Theory and Statistical Theory 18 units

The theory of probability gives a mathematical description of the randomness inherent in our observations. It is the language in which statistical models are stated, so an understanding of probability is essential for the study of statistical theory. Statistical theory provides a mathematical framework for making inferences about unknown quantities from data. The theory reduces statistical problems to their essential ingredients to help devise and evaluate inferential procedures. It provides a powerful and wide-ranging set of tools for dealing with uncertainty.

To satisfy the theory requirement take the following two courses**:

36-225	Introduction to Probability Theory	9
36-226	Introduction to Statistical Inference	9

**It is possible to substitute 36-217 or 21-325 for 36-225. (36-225 is the standard introduction to probability, 36-217 is tailored for engineers and computer scientists, and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.) 36-326 Mathematical Statistics (Honors) can be substituted for 36-226 Introduction to Statistical Inference and is considered an honors course.

Comments:

(i) In order to be a Major or a Minor in good standing, a grade of at least a C is required in 36-225, 36-226 and 36-401. In particular, a grade of C or higher is required in order to be able to continue in the major.

(ii) In special cases, and in consultation with the Statistics Advisor, the entire theory requirement can be satisfied by taking the *graduate level* class 36-625 Probability and Mathematical Statistics I, which is much more mathematically rigorous. This option should be considered by strong Statistics Majors who are also majoring in Computer Science, Operations Research, or Mathematics and/or who are considering graduate study in Statistics. This option requires special permission from the advisor. Students who end up satisfying the theory requirement by taking the (single) course

36-625 are required take an additional statistics elective (see category #6, Statistical Electives, below).

4. Computing:

64 - 67 units

Statistical modeling in practice nearly always requires computation in one way or another. Computational algorithms are sometimes treated as “black-boxes”, whose innards the statistician need not pay attention to. But this attitude is becoming less and less prevalent, and today there is much to be gained from a strong working knowledge of computational tools. Understanding the strengths and weaknesses of various methods allows the data analyst to select the right tool for the job; understanding how they can be adapted to work in new settings greatly extends the realm of problems that he/she can solve. While all Majors in Statistics are given solid grounding in computation, extensive computational training is really what sets the Major in Statistics and Machine Learning apart.

36-350	Statistical Computing	9
15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10
10-601	Introduction to Machine Learning	12
15-351	Algorithms and Advanced Data Structures	12

*A higher level Computer Science course approved by your Statistics advisor may be used as a substitute.

and take one of the following courses:

10-605	Machine Learning with Large Datasets	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-386	Neural Computation	9
16-720	Computer Vision	12
16-311	Introduction to Robotics	12
11-411	Natural Language Processing	12
11-761	Language and Statistics	12

*PhD level ML course as approved by Statistics advisor

** Independent research with an ML faculty member

Total number of units for the major 166-188 units

Total number of units for the degree 360 units

Recommendations

Students in the Dietrich College of Humanities and Social Sciences who wish to major or minor in Statistics are advised to complete both the calculus requirement (one Mathematical Foundations calculus sequence) and the Beginning Data Analysis course 36-201 Statistical Reasoning and Practice by the end of their Freshman year.

The linear algebra requirement is a prerequisite for the course 36-401. It is therefore essential to complete this requirement during your junior year at the latest!

Recommendations for Prospective PhD Students

Students interested in pursuing a PhD in Statistics or Machine Learning (or related programs) after completing their undergraduate degree are strongly recommended to take additional Mathematics courses. They should see a faculty advisor as soon as possible. Students should consider 36-326 Mathematical Statistics (Honors) as an alternative to 36-226. Although 21-240 Matrix Algebra with Applications is recommended for Statistics majors, students interested in PhD programs should consider taking 21-241 Matrices and Linear Transformations or 21-242 Matrix Theory instead. Additional courses to consider are 21-228 Discrete Mathematics, 21-260 Differential Equations, 21-341 Linear Algebra, 21-355 Principles of Real Analysis I, and 21-356 Principles of Real Analysis II.

Additional experience in programming and computational modeling is also recommended. Students should consider taking more than course from the list of Machine Learning electives provided under the Computing section.

Additional Major in Statistics and Machine Learning

Students who elect Statistics and Machine Learning as a second or third major must fulfill all degree requirements.

With respect to double-counting courses, it is departmental policy that students must have at least six courses (three Machine Learning and three Statistics) that do not count for their primary major. If students do not have at least six, they typically take additional advanced electives.

Students are advised to begin planning their curriculum (with appropriate advisors) as soon as possible. This is particularly true if the other major has a complex set of requirements and prerequisites or when many of the other major’s requirements overlap with the requirements for a Major in Statistics and Machine Learning.

Sample Programs

The following sample program illustrates one way to satisfy the requirements of the Statistics and Machine Learning program. Keep in mind that the program is flexible and can support other possible schedules (see footnotes below the schedule). Sample program 1 is for students who have not satisfied the basic calculus requirements. Sample program 2 is for students who have satisfied the basic calculus requirements and choose option 2 for their data analysis courses (see section #2)

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-122 Integration and Approximation	36-217 Probability Theory and Random Processes	21-241 Matrices and Linear Transformations
36-201 Statistical Reasoning and Practice	36-202 Statistical Methods	21-256 Multivariate Analysis	36-226 Introduction to Statistical Inference
15-112 Fundamentals of Programming and Computer Science	21-127 Concepts of Mathematics	36-350 Statistical Computing	15-122 Principles of Imperative Computation
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Junior		Senior	
Fall	Spring	Fall	Spring
15-351 Algorithms and Advanced Data Structures	36-402 Advanced Methods for Data Analysis	10-601 Introduction to Machine Learning	10-605 Machine Learning with Large Datasets
36-401 Modern Regression	Stat Elective	Stat Elective	ML Elective
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*In each semester, ----- represents other courses (not related to the major) which are needed in order to complete the 360 units that the degree requires.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-256 Multivariate Analysis	15-122 Principles of Imperative Computation	36-217 Probability Theory and Random Processes	21-241 Matrices and Linear Transformations
15-112 Fundamentals of Programming and Computer Science	21-127 Concepts of Mathematics	15-351 Algorithms and Advanced Data Structures	36-226 Introduction to Statistical Inference
-----*	-----	-----	Stat Elective
-----	-----	-----	-----
-----	-----	-----	-----

Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-402 Advanced Methods for Data Analysis	10-601 Introduction to Machine Learning	10-605 Machine Learning with Large Datasets
36-401 Modern Regression	Stat Elective	Stat Elective	ML Elective
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-----	-----	-----	-----
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*In each semester, ----- represents other courses (not related to the major) which are needed in order to complete the 360 units that the degree requires.

The Minor in Statistics

Academic Advisor: Paige Houser
 Faculty Advisor: Howard Seltman
 Office: Baker Hall 132A
 Email: acadcoord@stat.cmu.edu

The Minor in Statistics develops skills that complement major study in other disciplines. The program helps the student master the basics of statistical theory and advanced techniques in data analysis. This is a good choice for deepening understanding of statistical ideas and for strengthening research skills.

In order to get a minor in Statistics a student must satisfy all the requirements in categories 1, 2 and 3 of the major requirement (see above) with the exception that in the advanced data analysis part only 36-401 and 36-402 are required. In other words, the requirements for the minor are (read the section about the Major in Statistics for details):

1. Mathematical Foundations (Prerequisites)28-38 units
Identical to Major requirements (read relevant section above carefully).

2. Data Analysis36 units

Beginning Data Analysis: 9 units (one course) - see Major requirements above.

Intermediate Data Analysis: 9 units (one course) - see Major requirements above.

Advanced Data Analysis: 18 units - 36-401 and 36-402

3. Probability Theory and Statistical Theory18 units
Identical to Major requirements (read relevant section above carefully).

Total number of units required for the minor **82 Units**

With respect to double-counting courses, it is departmental policy that students must have at least three statistics courses that do not count for their primary major. If students do not have at least three, they typically take additional advanced electives.

Sample Programs for the Minor

The following two sample programs illustrates two (of many) ways to satisfy the requirements of the Statistics Minor. Keep in mind that the program is flexible and can support many other possible schedules.

The first schedule uses calculus sequence 1, and 36-309 to satisfy the intermediate data analysis requirement. The second schedule is an example of the case when a student enters the Minor through 36-225 and 36-226 (and therefore skips the beginning data analysis course). The schedule uses calculus sequence 2, and 36-315 as an elective (to replace the beginning data analysis course).

Schedule 1

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-111 Calculus I	21-112 Calculus II	21-256 Multivariate Analysis	21-240 Matrix Algebra with Applications
36-201 Statistical Reasoning and Practice		36-309 Experimental Design for Behavioral and Social Sciences	

Junior		Senior	
Fall	Spring	Fall	Spring
36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference	36-401 Modern Regression	36-402 Advanced Methods for Data Analysis

Schedule 2

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference

Junior		Senior	
Fall	Spring	Fall	Spring
21-240 Matrix Algebra with Applications	36-315 Statistical Graphics and Visualization	36-401 Modern Regression	36-402 Advanced Methods for Data Analysis

Substitutions and Waivers

Many departments require Statistics courses as part of their Major or Minor programs. Students seeking transfer credit for those requirements from substitute courses (at Carnegie Mellon or elsewhere) should seek permission from their advisor in the department setting the requirement. The final authority in such decisions rests there. The Statistics Department does not provide approval or permission for substitution or waiver of another department's requirements.

However, the Statistics Director of Undergraduate Studies will provide advice and information to the student's advisor about the viability of a proposed substitution. Students should make available as much information

as possible concerning proposed substitutions. Students seeking waivers may be asked to demonstrate mastery of the material.

Statistics Majors and Minors seeking substitutions or waivers should speak to the Statistics Director of Undergraduate Studies.

Faculty

XIZHEN CAI, Assistant Teaching Professor - Ph.D., The Pennsylvania State University; Carnegie Mellon, 2014-.

DAVID CHOI, Assistant Professor of Statistics and Information Systems - Ph.D., Stanford University; Carnegie Mellon, 2004-.

ALEXANDRA CHOULDECHOVA, Assistant Professor of Statistics and Public Policy - Ph.D., Stanford University; Carnegie Mellon, 2014-.

STEPHEN E. FIENBERG, University Professor and Maurice Falk Professor of Statistics and Social Sciences - Ph.D., Harvard University; Carnegie Mellon, 1980-.

MAX G'SELL, Assistant Professor - Ph.D., Stanford University; Carnegie Mellon, 2014-.

CHRISTOPHER GENOVESE, Department Head and Professor of Statistics - Ph.D., University of California, Berkeley; Carnegie Mellon, 1994-.

JOEL B. GREENHOUSE, Professor of Statistics - Ph.D., University of Michigan; Carnegie Mellon, 1982-.

AMELIA HAVILAND, Anna Loomis McCandless Professorship of Statistics and Public Policy - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2003-.

JIASHUN JIN, Professor of Statistics - Ph.D., Stanford University; Carnegie Mellon, 2007-.

BRIAN JUNKER, Associate Dean and Professor of Statistics - Ph.D., University of Illinois; Carnegie Mellon, 1990-.

ROBERT E. KASS, Professor of Statistics - Ph.D., University of Chicago; Carnegie Mellon, 1981-.

ANN LEE, Associate Professor - Ph.D., Brown University; Carnegie Mellon, 2005-.

JOHN P. LEHOCZKY, Thomas Lord Professor of Statistics - Ph.D., Stanford University; Carnegie Mellon, 1969-.

JING LEI, Assistant Professor - Ph.D., University of California, Berkeley; Carnegie Mellon, 2011-.

DANIEL NAGIN, Teresa and H. John Heinz III Professor of Public Policy - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1976-.

REBECCA NUGENT, Teaching Professor - Ph.D., University of Washington; Carnegie Mellon, 2006-.

ALESSANDRO RINALDO, Associate Professor - Ph.D., Carnegie Mellon; Carnegie Mellon, 2005-.

KATHRYN ROEDER, Professor of Statistics - Ph.D., Pennsylvania State University; Carnegie Mellon, 1994-.

CHAD M. SCHAFER, Associate Professor - Ph.D., University of California, Berkeley; Carnegie Mellon, 2004-.

MARK J. SCHERVISH, Professor of Statistics - Ph.D., University of Illinois; Carnegie Mellon, 1979-.

TEDDY SEIDENFELD, Herbert A. Simon Professor of Philosophy and Statistics - Ph.D., Columbia University; Carnegie Mellon, 1985-.

COSMA SHALIZI, Associate Professor - Ph.D., University of Wisconsin, Madison; Carnegie Mellon, 2005-.

RYAN TIBSHIRANI, Assistant Professor - Ph.D., Stanford University; Carnegie Mellon, 2011-.

VALERIE VENTURA, Associate Professor - Ph.D., University of Oxford; Carnegie Mellon, 1997-.

LARRY WASSERMAN, Professor of Statistics - Ph.D., University of Toronto; Carnegie Mellon, 1988-.

Emeriti Faculty

GEORGE T. DUNCAN, Professor of Statistics and Public Policy - Ph.D., University of Minnesota; Carnegie Mellon, 1974-.

WILLIAM F. EDDY, John C. Warner Professor of Statistics - Ph.D., Yale University; Carnegie Mellon, 1976-.

JOSEPH B. KADANE, Leonard J. Savage Professor of Statistics and Social Sciences – Ph.D., Stanford University; Carnegie Mellon, 1969–.

Adjunct Faculty

ANTHONY BROCKWELL, – Ph.D., Melbourne University; Carnegie Mellon, 1999–.

BERNIE DEVLIN, – Ph.D., Pennsylvania State University; Carnegie Mellon, 1994–.

Special Faculty

PETER FREEMAN, Research Associate – Ph.D., University of Chicago; Carnegie Mellon, 2004–.

HOWARD SELTMAN, Senior Research Statistician – Ph.D., Carnegie Mellon; M.D., Medical College of Pennsylvania; Carnegie Mellon, 1999–.

ISABELLA VERDINELLI, Professor in Residence – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1991–.

GORDON WEINBERG, Lecturer – M.A. Mathematics, University of Pittsburgh; Carnegie Mellon, 2004–.

Visiting Faculty

JARED MURRAY, Assistant Professor – Ph.D., Duke University; Carnegie Mellon, 2013–.

JORDAN RODU, Assistant Professor – Ph.D., University of Pennsylvania ; Carnegie Mellon, 2014–.

SAM VENTURA, Assistant Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2015–.

H. John Heinz III College

Ramayya Krishnan, Dean
Office: 1509 Hamburg Hall
<http://www.heinz.cmu.edu/>

Students entering graduate programs at Carnegie Mellon University's H. John Heinz III College are accomplished, talented and committed to improving the ability of public, non-profit and private organizations to address the most difficult challenges facing society, as well as to strengthen and exploit our cultural resources through skilled leadership and management. Students gain the skills and knowledge necessary to transform that talent and commitment into a successful career and a positive force for change.

Unlike many graduate schools, we are not organized along academic departments. Faculty from our two schools -- the School of Public Policy and Management (<http://www.heinz.cmu.edu/school-of-public-policy-management>) and the School of Information Systems and Management (<http://www.heinz.cmu.edu/school-of-information-systems-and-management>) -- collaborate on instruction and research, an operating model we believe leads to innovation in research and a superior educational experience. Our strengths span the applied disciplines of empirical methods and statistics, economics, information systems and technology, operations research and organizational behavior.

Heinz College is a dynamic community of scholars and practitioners developing fundamental knowledge about and seeking innovative, applied solutions to today's most critical problems of the public, private and non-profit sectors.

Options for Carnegie Mellon Undergraduates

Heinz College does not offer undergraduate degrees. It does offer two study options, however, for students pursuing Carnegie Mellon undergraduate degrees - 1) Accelerated Master's Program (AMP), and 2) undergraduate minor in Health Care Policy and Management (see below).

Five-Year (Accelerated) Master's Programs

Heinz College's Accelerated Master's Program (AMP) allows qualified students to earn a prestigious master's degree in just five years (CMU undergrads can complete their master's degree in just one additional year of study beyond their bachelor's degree).

The following master's degrees provide an AMP and are open to students from all departments at the university:

- Master of Arts Management (MAM)
- Master of Information Systems Management (MISM)
- Master of Science in Health Care Policy and Management (MSHCPM)
- Master of Science in Information Security Policy and Management (MSISPM)
- Master of Science in Public Policy and Management (MSPPM)

In addition to the accelerated master's programs, Heinz offers traditional graduate degree programs (full-time study required):

- Master of Science in Public Policy and Management (MSPPM), with options that include:
 - concentration in Policy Analytics (POLA)
 - dual degree MSPPM/MBA program with the Tepper School of Business
 - dual degree MSPPM/JD program with the University of Pittsburgh School of Law
 - dual degree MSPPM/MDiv program with the Pittsburgh Theological Seminary
 - one year of study at the main campus in Pittsburgh and one year of study/experiential learning at our location in Washington, DC
 - one year of study at our campus in Australia and one year in Pittsburgh
- Master of Arts Management (MAM), with options that include
 - a dual degree MAM/JD program with the University of Pittsburgh School of Law
 - dual degree MAM/GIOCA that includes one year (3 semesters) of study at the main campus in Pittsburgh and two years of study/experiential learning at the University of Bologna, Italy

- Master of Entertainment Industry Management (MEIM)
- Master of Science in Health Care Policy and Management, with the option to pursue:
 - dual degree MSHCPM/MBA program with the Tepper School of Business
- Master of Science in Biotechnology and Management (MSBTM)
- Master of Information Systems Management (MISM), with options that include:
 - concentration in Business Intelligence and Data Analytics (BIDA) track
 - one year of study at our campus in Australia and one year in Pittsburgh
- Master of Science in Information Security Policy and Management (MSISPM)
- Doctor of Philosophy in Public Policy and Management (Ph.D.-PPM)
- Doctor of Philosophy in Information Systems (Ph.D.-ISM)

Heinz offers graduate degree programs for individuals with prior work experience:

- Master of Public Management (MPM)
 - full-time and part-time options available
- Master of Science in Information Technology (MSIT)
 - part-time study with the option to pursue degree via distance learning or on-campus
- Master of Medical Management (MMM)
 - includes distance and limited on-campus study components

Minor in Health Care Policy and Management

Sponsored by:

H. John Heinz III College
Dietrich College of Humanities and Social Sciences
Mellon College of Science

Faculty Advisors:

Jason D'Antonio, Mellon College of Science
James F. Jordan, H. John Heinz III College

The face of health care is changing. The practice of medicine is being fundamentally altered by the forces of change in public policy, health care organizations and in the industry as a whole. The role of individual professionals in this industry is changing as rapidly as the industry itself. Traditional career paths have disappeared overnight to be replaced by new opportunities that require new skills. New organizations are placing new demands on their professional and medical staffs. The criteria of efficiency and financial stability are entering the domains of diagnosis and treatment.

This minor is designed to provide students considering a career in the health professions with an understanding of how these changes are likely to affect their careers. Students will become familiar with the critical policy and management issues and will begin to learn to operate effectively in the emerging health care environment. The curriculum combines economic, organizational, managerial, historical and psychological perspectives on these issues to provide a foundation for a deepened understanding of the changing structure of health care organizations and policy.

Curriculum

60 units minimum

Seven courses (a minimum of 60 units) are required to complete this minor. Entry into the minor requires completion of 73-100 Principles of Economics or 88-220 Policy Analysis I or the equivalent by approval.

Required Courses

39 units

Students are required to take the following courses.

79-330	Medicine and Society	9
90-836	Health Systems	6
90-861	Health Policy	6
94-705	Health Economics	12

Elective Courses**27 units**

Complete a minimum of 27 units.

Heinz College Courses

90-708	Healthcare Ethics	6
90-721	Healthcare Management	6
90-818	Health Care Quality & Performance Improvement	6
90-830	Introduction to Financial Management of Health Care	6
90-831	Advanced Financial Management of Health Care	6
90-832	Health Law	6
90-863	Health Policy II	6
94-706	Healthcare Information Systems	12
Humanities and Social Sciences Courses (9 units each)		
76-494	Healthcare Communications	9
79-383	Epidemics, Disease, and Public Health	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
85-241	Social Psychology	9
85-442	Health Psychology	9
85-446	Psychology of Gender	9

Please note that some of these courses have prerequisites that will not count toward the completion of the requirements for this minor.

What kinds of careers do Heinz College graduates pursue?

A Heinz College degree opens doors to a wide range of professional careers in government agencies, nonprofit organizations, consulting firms, arts groups, foundations, private businesses and a host of other organizations. Heinz College graduates can get the kind of interesting, exciting jobs they want, because they have the expertise in policy, management, finance, information systems, and decision-making that employers need.

Heinz College's Ph.D. program in particular prepares qualified students from a variety of academic and professional backgrounds for careers in research, academia, government-related organizations and the private sector, in positions where expertise in advanced research is desired. Graduates of the Ph.D. program work as professors, research scientists, research directors and consultants, across diverse areas of public service and management.

Some of the jobs that have been held by Heinz College graduates include:

- Budget Analyst, Congressional Budget Office
- President/Chief Executive Officer, Urban League of Philadelphia
- Vice President, Public Finance Division, Donaldson, Lufkin & Jenrette Securities Corp.
- Executive Director, Allegheny Conference on Community Development
- Executive Director, Maryland Small Business Development Financing Authority
- District Manager, AT&T Consumer Information
- Senior Consultant, Ernst and Young
- Director of Marketing, Bardavon 1869 Opera House, Poughkeepsie, NY
- Consultant, Hill Arts and Entertainment
- Special Projects Coordinator, Washington Very Special Projects
- Managing Director, Misnomer Dance Theater
- Business Development & Licensing, Warner Bros.

How is Heinz College different?

Diversity

Heinz College's student body is internationally recognized for its diversity in ethnicity, gender and citizenship. It also is diverse in terms of students' academic backgrounds, which include undergraduate degrees in architecture, biology, business administration, computer science, economics, education, engineering, English, fine arts, government, history, information systems, philosophy, political science, sociology and many other fields.

Practical Experience

Heinz College doesn't just teach skills in the classroom:

- Through the systems synthesis project, students work in teams to analyze and develop solutions for current international, national and local problems and present their findings to the real-world client.
- Students complete a summer internship to practice the skills they've learned in school.

Impact on Society

The expertise of a renowned faculty is transferred to society through the education and research mission of Heinz College, as well as the efforts of its policy and research centers. These include the Arts Management and Technology Laboratory, Traffic21, Living Analytics Research Centre, Initiative for Digital Entertainment Analytics (IDEA), Center for Economic Development, and the Center for the Future of Work. Heinz College students can work on projects initiated in these centers or as research assistants for center faculty.

Global Heinz

With multiple locations around the United States and the world, Heinz College offers students the opportunity to gain a global perspective while pursuing their master's degree.

Since 2006, the Adelaide campus has served as the school's Asia Pacific education base and currently offers two master's level degrees - MSPPM and MSIT.

Heinz College's Washington, D.C. center (established in 2008) connects our public policy students with national and international policy makers and organizations. The goal is to create a dynamic and productive network that benefits our community at large and brings the unique strengths of Carnegie Mellon to positively impact the public interest. The office also serves as classroom space for 2nd year MSPPM students in the program's D.C. track.

The Master of Entertainment Industry Management (MEIM) program trains a new generation of leaders in the entertainment industry. Students spend a year in Pittsburgh followed by a year in Los Angeles exploring how management theories and principles are applied in the film and television industries.

Additional information can be found on our website: <http://www.heinz.cmu.edu>.

The Faculty

Heinz College faculty members have been recognized nationally and internationally for their accomplishments in research and their contributions to public policy. Their backgrounds are in economics, operations research, information systems and technology, fine arts, sociology, public policy, statistics, organizational management and behavior, finance, statistics, labor relations, and demography among other areas. The right is information on many full-time Carnegie Mellon University faculty members who teach and do research at Heinz College. For a more complete, current list, visit <http://www.heinz.cmu.edu/directories/faculty-directory/index.aspx>.

For further information about Heinz College, contact:

Director of Admissions
H. John Heinz III College
Carnegie Mellon University
Pittsburgh, PA 15213

Telephone: (412) 268-2164
Toll-free (U.S.): 1-800-877-3498
Fax: (412) 268-7036
Email: hznadmit@andrew.cmu.edu
Website: <http://www.heinz.cmu.edu>

Faculty

ALESSANDRO ACQUISTI, Assistant Professor of Information Systems and Public Policy - Ph.D., UC Berkeley; Carnegie Mellon, 2003-.

SHAMENA ANWAR, Assistant Professor of Economics and Public Policy - Ph.D., Yale University; Carnegie Mellon, 2007-.

LINDA BABCOCK, James M. Walton Professor of Economics - Ph.D., University of Wisconsin at Madison; Carnegie Mellon, 1988-.

EDWARD BARR, Associate Teaching Professor - M.S., Indiana University of Pennsylvania; Carnegie Mellon, 2000-.

ALFRED BLUMSTEIN, J. Erik Jonsson University Professor of Urban Systems and Operations Research; Director, National Consortium on Violence Research - Ph.D., Cornell University; Carnegie Mellon, 1969-.

- SILVIA BORZUTSKY, Associate Teaching Professor – Ph.D., University of Pittsburgh; Carnegie Mellon, 2001–.
- LEE BRANSTETTER, Associate Professor of Economics – Ph.D., Harvard University; Carnegie Mellon, 2006–.
- KATHLEEN CARLEY, Professor of Organizational Sociology – Ph.D., Harvard University; Carnegie Mellon, 2011–.
- JONATHAN CAULKINS, Professor of Operations Research and Public Policy; Faculty Chair, Master of Public Policy and Management Program – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1990–.
- JACK CHOW, Distinguished Service Professor – M.D., University of California at San Francisco School of Medicine; Carnegie Mellon, 2011–.
- KAREN CLAY, Assistant Professor of Economics and Public Policy – Ph.D., Stanford University; Carnegie Mellon, 1997–.
- JACQUELINE COHEN, Principal Research Scientist – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1982–.
- WESLEY COHEN, (Affiliated) Professor of Economics and Social Sciences – Ph.D., Yale University; Carnegie Mellon, 1982–.
- LAURA DABBISH, Assistant Professor of Information Technology and Organizations – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2006–.
- GEORGE T. DUNCAN, Professor of Statistics, Emeritus – Ph.D., University of Minnesota; Carnegie Mellon, 2011–.
- DENNIS EPPEL, (Affiliated) Thomas Lord Professor of Economics – Ph.D., Princeton University; Carnegie Mellon, 1974–.
- JENDAYI E. FRAZER, Distinguished Service Professor – Ph.D., Stanford University; Carnegie Mellon, 2011–.
- MARTIN GAYNOR, E.J. Barone Professor of Economics and Health Policy; Faculty Chair, Ph.D. Program – Ph.D., Northwestern University; Carnegie Mellon, 1995–.
- WILPEN GORR, Professor of Public Policy and Management Information Systems – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1985–.
- ROBERT HAMPSHIRE, Assistant Professor of Operations Research and Public Policy – Ph.D., Princeton University; Carnegie Mellon, 2007–.
- JAMES F. JORDAN, Distinguished Service Professor – M.B.A., Boston University; Carnegie Mellon, 2011–.
- MARK S. KAMLET, Provost, CMU, and H. John Heinz III Professor of Economics and Public Policy – Ph.D., University of California at Berkeley; Carnegie Mellon, 1978–.
- WILLIAM P. KITTREDGE, Associate Teaching Professor – Ph.D., Maxwell School of Public Affairs and Citizenship; Carnegie Mellon, 2011–.
- STEVEN KLEPPER, (Affiliated) Professor of Economics and Social Science – Ph.D., Cornell University; Carnegie Mellon, 1980–.
- DAVID KRACKHARDT, Professor of Organizations and Public Policy – Ph.D., University of California at Irvine; Carnegie Mellon, 1991–.
- RAMAYYA KRISHNAN, William W. and Ruth F. Cooper Professor of Management Science and Information Systems; Faculty Chair, Master of Information Systems Management Program – Ph.D., University of Texas at Austin; Carnegie Mellon, 1987–.
- KRISTIN KURLAND, Associate Teaching Professor (joint with School of Architecture) – B.A., University of Pittsburgh; Carnegie Mellon, 1999–.
- LESTER LAVE, James Higgins Professor of Economics and Finance, Professor of Urban and Public Affairs, Professor of Engineering and Public Policy – Ph.D., Harvard University; Carnegie Mellon, 1963–.
- GORDON LEWIS, Associate Professor of Sociology; Faculty Chair, Master of Public Management Program – Ph.D., Stanford University; Carnegie Mellon, 1969–.
- PAMELA LEWIS, Teaching Professor of Professional Speaking – D.A., Carnegie Mellon University; Carnegie Mellon, 1980–.
- ARI LIGHTMAN, Practice Professor, Digital Media and Marketing – M.B.A., Carnegie Mellon University; Carnegie Mellon, 2011–.
- PETER MADSEN, Senior Lecturer in Ethics and Public Policy – Ph.D., Duquesne University; Carnegie Mellon, 1988–.
- DONALD MARINELLI, (Affiliated) Professor of Drama and Arts Management (College of Fine Arts) – Ph.D., University of Pittsburgh; Carnegie Mellon, 1984–.
- DAN MARTIN, Director, Master of Arts Management Program, and Associate Professor (College of Fine Arts) – M.F.A., Brooklyn College/City University of New York; Carnegie Mellon, 1993–.
- MICHAEL MCCARTHY, Associate Teaching Professor of Information Systems Management – M.S., University of Pittsburgh; Carnegie Mellon, 1999–.
- JOE MERTZ, Associate Teaching Professor – Ph.D., Carnegie Mellon; Carnegie Mellon, 1994–.
- KARYN MOORE, Assistant Teaching Professor of Information Systems – M.S., Industrial Administration, Carnegie Mellon University; Carnegie Mellon, 2003–.
- M. GRANGER MORGAN, Lord Chair Professor of Engineering and Public Policy, and Head, Department of Engineering and Public Policy – Ph.D., University of California at San Diego; Carnegie Mellon, 1974–.
- DANIEL NAGIN, Theresa and H. John Heinz III Professor of Public Policy, and Research Director, National Consortium on Violence Research – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1979–.
- DANIEL NEILL, Assistant Professor of Information Systems – M.S., University of Pittsburgh; Carnegie Mellon, 2007–.
- ERIC NYBERG, Assistant Professor of Computer Science and Public Policy (joint with School of Computer Science) – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1986–.
- REMA PADMAN, Professor of Operations Research and Information Management; Faculty Chair, Master of Science in Health Care Policy and Management Program – Ph.D., University of Texas at Austin; Carnegie Mellon, 1989–.
- LYNNE PASTOR, Visiting Associate Teaching Professor – M.S., Industrial Administration, Carnegie Mellon University; Carnegie Mellon, 2007–.
- SETH RICHARDS-SHUBIK, Assistant Professor of Economics and Public Policy – Ph.D., University of Pennsylvania; Carnegie Mellon, 2011–.
- STEPHEN ROEHRIG, Associate Professor of Information Systems and Public Policy – Ph.D., University of Pennsylvania Wharton School; Carnegie Mellon, 1991–.
- DENISE ROUSSEAU, H. J. Heinz II Professor of Organizational Behavior (joint with Graduate School of Industrial Administration) – Ph.D., University of California at Berkeley; Carnegie Mellon, 1994–.
- KIRON SKINNER, (Courtesy) Assistant Professor of History and Political Science – Ph.D., Harvard University; Carnegie Mellon, 1999–.
- DONALD SMITH, Professor of Practice; University Director for Economic Development – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1995–.
- KATHLEEN SMITH, Associate Teaching Professor – Ph.D., candidate, University of Pittsburgh; Carnegie Mellon, 1991–.
- MICHAEL SMITH, Assistant Professor of Information Technology – Ph.D., Alfred P. Sloan School of the Massachusetts Institute of Technology; Carnegie Mellon, 2000–.
- RICHARD STAFFORD, Distinguished Service Professor – M.S., Public Policy and Management, Carnegie Mellon University; Carnegie Mellon, 2005–.
- SHELBY STEWMAN, Professor of Sociology and Demography – Ph.D., Michigan State University; Carnegie Mellon, 1973–.
- ROBERT STRAUSS, Professor of Economics and Public Policy; Faculty Chair, Master of Science in Educational Technology Management Program – Ph.D., University of Wisconsin; Carnegie Mellon, 1979–.
- LAURA SYNNOTT, Associate Teaching Professor, Healthcare Policy and Management – M.S., Health Services Administration, University of Michigan; Carnegie Mellon, 2004–.
- JANUSZ SZCZYPULA, Associate Teaching Professor in Information Systems – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2000–.
- JOEL TARR, Richard S. Caliguiri Professor of Urban and Environmental History and Policy – Ph.D., Northwestern University; Carnegie Mellon, 1967–.
- LOWELL TAYLOR, Professor of Economics and Public Policy; Associate Dean of Faculty – Ph.D., University of Michigan; Carnegie Mellon, 1990–.
- RAHUL TELANG, Assistant Professor of Information Systems – Ph.D., Carnegie Mellon; Carnegie Mellon, 2001–.
- MARK WESSEL, Dean University of Wisconsin; Carnegie Mellon, 1992–.
- TIM ZAK, Associate Teaching Professor – M.B.A., New York University; Carnegie Mellon, 2011–.

Mellon College of Science

Frederick J. Gilman, Dean
 Eric W. Grotzinger, Associate Dean for Undergraduate Affairs
 Maggie Braun, Director of Core Education
 John F. Hannon, Director of Integrative Learning
 Undergraduate Office: Doherty Hall 1324
<http://www.cmu.edu/mcs/>

The Mellon College of Science (MCS) has provided the undergraduate training for many of today's leading scientists. We have earned national recognition for our integration of undergraduate education and research from such organizations as the National Science Foundation, the Howard Hughes Medical Institute, and the Beckman Foundation. MCS students gain a broad education in science, mathematics, and the liberal arts while using state-of-the-art computational approaches in their courses, laboratories, and research activities. Our faculty members are committed to teaching as well as to a wide range of scientific research. This combined emphasis on education and research brings special benefits to students, including increased awareness of current scientific developments that are incorporated in classroom instruction, and, most importantly, opportunities to participate with faculty, graduate students, and other research scientists in a variety of research projects.

In the context of rigorous training in each field, the MCS curriculum emphasizes problem-solving, communication, and analytical skills, and it teaches our students the value of hard work and discipline. Our students go on to highly successful careers in a broad range of fields like astrophysics, biotechnology, computer science, business management, environmental science, health care policy, investment banking, marketing analysis, medicine, patent law, and pharmaceuticals. Our alumni credit their education in science for preparing them for a lifetime of learning and achievement; their employers attest to their ability to succeed and to continue learning in an ever-changing world.

The MCS Departments of Biological Sciences, Chemistry, Mathematical Sciences, and Physics each outline their degree programs and courses in the departmental sections. Students select their major in the spring of the first year so that the sophomore year begins with a focus within a department. Most of the courses required within a major are scheduled in the sophomore and junior years, leaving much of the senior year and part of the junior year open for electives. This provides the opportunity to participate in undergraduate research, explore interdisciplinary studies, study abroad, pursue additional majors or minors in other fields, or take other specialty courses oriented toward immediate job placement upon graduation or entry into graduate studies.

Tailoring Your Education

The Mellon College of Science offers students tremendous opportunity for tailoring their education to meet individual professional objectives. Whether you target your degree to a particular field in your discipline via departmental options and concentrations, add a secondary major, minor, or degree to your primary degree program, participate in honors programs, or pursue a master's degree along with your bachelor's degree, MCS has much to offer you. Many of these opportunities are outlined below.

Departmental Concentrations

Each department in MCS offers degrees and programs that allow students to explore particular fields within a science discipline. These are outlined below — see the departmental sections for further details.

Biological Sciences

- Biochemistry
- Biophysics
- Cell Biology
- Computational Biology
- Developmental Biology
- Genetics
- Molecular Biology
- Neuroscience

Chemistry

- Biochemistry
- Biological Chemistry

- Colloids, Polymers, and Surfaces
- Computational Chemistry
- Environmental Chemistry
- Management
- Material Chemistry
- Polymer Science

Mathematical Sciences

- Computational and Applied Mathematics
- Computational Finance
- Discrete Mathematics and Logic
- Mathematics
- Operations Research
- Statistics

Physics

- Applied Physics
- Astrophysics
- Biological Physics
- Chemical Physics
- Computational Physics

Minors, Double Majors, and Double Degrees

As an MCS student, you can pursue additional majors and minors to complement your primary degree, not only within the science college, but also through the other colleges at Carnegie Mellon. Carnegie Mellon offers many exciting interdisciplinary majors and minors, some of which are listed below. In addition, every college and most departments have designed minors or second majors in their discipline so that you can gain expertise in their fields as well.

Some students choose to gain this expertise by following a double degree program. This results in two distinct bachelor's degrees. Please see the section on Undergraduate Academic Regulations for a more formal definition of these "Multiple Degree" programs.

Interdisciplinary Majors and Minors

Here is a sampling of just a few of the interdisciplinary minors and majors offered at Carnegie Mellon. Please see the appropriate sections elsewhere in this catalog for specific descriptions and course requirements.

- Biological Sciences and Psychology Major
- Computational Biology Major
- Computer Science Minor
- Engineering Studies Minor
- Environmental Policy Major
- Health Care Policy and Management Minor
- International Affairs Minor
- Mathematics and Economics Major
- Robotics Minor
- Scientific Computing Minor
- Technology and Policy Minor

For a complete list of the minors offered at Carnegie Mellon, please go to <http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/>

University Self-Defined Majors

With a well-thought proposal, you may be able to pursue a major you have designed to meet your particular interests and goals. Please see the catalog section on Undergraduate Options at <http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/>

Honors Degree Programs in MCS

Several of the departments in MCS offer students an opportunity to participate in a departmental honors degree program. Some of these programs result in a master's degree along with the bachelor's degree (see next section on accelerated master's programs). These programs are listed below; see the department's section of the catalog for more details.

- Honors Program in Research Biology
- Departmental Honors in Chemistry
- Honors B.S./M.S. Program in Chemistry
- Honors B.S./M.S. Program in Mathematical Sciences

Accelerated Master's Programs

Carnegie Mellon offers some accelerated master's programs for motivated students, whereby students complete both the bachelor's and the master's degree in four or five years. Some programs are in the student's home department in MCS as part of an honors program, while others are offered through one of our graduate schools at Carnegie Mellon. Below is a listing of the programs currently available to MCS students; please see the appropriate sections of the catalog for more details.

- Honors B.S./M.S. Program in Chemistry
- Honors B.S./M.S. Program in Mathematical Sciences
- Accelerated Master's Program in the Heinz College

Study Abroad

There are many programs for studying abroad, usually during your junior year. Please see the catalog section on Undergraduate Options for more details, and talk with the Office of International Education to get information and advice specifically for you.

Pre-Professional Programs

Many students in the Mellon College of Science decide to pursue professional training such as medical school or law school after completing their undergraduate work. Carnegie Mellon offers strong advising services to support these students. Through these programs, students get help with everything from course selection to identification of important experiential opportunities to the application process itself.

Health Professions Program

Faculty Contact: Jason D'Antonio

Please see the Undergraduate Options (p. 65) section for details on the Health Professions Program.

Pre-Law Advising Program

Faculty Contact: Joseph Devine

Please see the Undergraduate Options (p.) section for details on the Pre-Law Advising Program.

General Education Requirements

For Students Entering Prior to the Fall of 2015

Technical Breadth Requirements

An MCS education is based on a broad foundation in the sciences: two semesters each of calculus and physics and one semester each of biology, chemistry and computer science. This foundation corresponds to the following courses required for all MCS students.

03-121	Modern Biology	9
09-105	Introduction to Modern Chemistry I	10
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
or 02-201	Programming for Scientists	
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	

33-111	Physics I for Science Students	12
or 33-121	Physics I for Science Students	
33-112	Physics II for Science Students	9-12
or 33-122	Physics II for Biological Sciences and Chemistry Students	
or 33-142	Physics II for Engineering and Physics Students	

In the first year, students take two semesters of calculus, 21-120 Differential and Integral Calculus and 21-122 Integration and Approximation or 21-124 Calculus II for Biologists and Chemists. They also take three of the remaining five science core courses. The other two science core courses are completed by the end of the junior year. Additional courses in the first year include one course from the intended major; humanities, social sciences or fine arts courses; and Computing @ Carnegie Mellon, a course that introduces students to the computing environment and ethics of computing at Carnegie Mellon.

With this broad science background, a student is prepared to undertake any of the degree programs offered by the college when selecting a major at the end of the first year.

Sample First Year Schedule

Fall Semester 44-50 units

21-120	Differential and Integral Calculus	10
xx-xxx	Science Core Course	9-12
xx-xxx	Science Core Course	10
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
xx-xxx	Optional First-Year Seminar or Discovery-Based Lab	3-6

Spring Semester 46-53 units

21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
xx-xxx	Science Core Course	9-12
xx-xxx	Departmental Elective from Intended Major	9-10
xx-xxx	Humanities, Social Sciences, or Fine Arts Course	9
xx-xxx	Optional Free Elective Course or Discovery-Based Lab	6-9
xx-xxx	Optional First-Year Seminar	3

Notes:

1. Departmental electives from the intended major are as follows:

Biological Sciences or Chemistry:
09-106 Modern Chemistry II (10 units)

Mathematical Sciences
21-127 Concepts of Mathematics (10 units)

Physics
33-104 Experimental Physics (9 units)

2. A free elective is any Carnegie Mellon course. However, a maximum of nine units of physical education, military science and/or STUCO courses may be taken as free electives in any MCS degree program. Credit earned for physical education, military science and STUCO courses will not be calculated in a student's QPA.
3. Students who enter with advanced placement credits will follow a similar schedule with modifications for their AP work

Humanities, Social Sciences, and Fine Arts Requirements

All candidates for the bachelor's degree must complete a minimum of 72 units offered by the Dietrich College of Humanities and Social Science and/or the College of Fine Arts. These courses for MCS students are to meet the following distribution requirements:

A. Designated Writing Course (9 units)

76-101	Interpretation and Argument	9
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B. Distributional Course Requirements (27 units)

Complete three courses, one each from Category 1, Category 2, and Category 3. Listed below are examples of courses that meet the requirement for each category. Students wishing to substitute a course that is not listed should meet with their advisor.

Category 1: Cognition, Choice and Behavior

80-100	Introduction to Philosophy	9
80-130	Introduction to Ethics	9
80-150	Nature of Reason	9
80-180	Nature of Language	9
80-208	Critical Thinking	9
80-220	Philosophy of Science	9
80-221	Philosophy of Social Science	9
80-230	Ethical Theory	9
80-241	Ethical Judgments in Professional Life	9
80-270	Philosophy of Mind	9
80-271	Philosophy and Psychology	9
80-312	Philosophy of Mathematics	9
85-102	Introduction to Psychology	9
85-211	Cognitive Psychology	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9
85-261	Abnormal Psychology	9
85-390	Human Memory	9
88-120	Reason, Passion and Cognition	9

Category 2: Economic, Political and Social Institutions

19-101	Introduction to Engineering and Public Policy	12
36-303	Sampling, Survey and Society	9
70-332	Business, Society and Ethics	9
70-420	Entrepreneurship for Scientists	9
73-100	Principles of Economics	9
79-203	Social and Political Change in 20th Century Central and Eastern Europe	9
79-205	20th Century Europe	9
79-221	Development and Democracy in Latin America	9
79-245	Capitalism and Individualism in American Culture	9
79-246	Industrial America	9
79-252	Recent U.S. History, 1945-Present	9
79-316	Photography, the First 100 Years, 1839-1939	9
79-330	Medicine and Society	9
79-331	Body Politics: Women and Health in America	9
79-340	Juvenile Delinquency and Juvenile Justice	9
79-341	The Cold War in Documents and Film	9
79-374	American Environmental History: Critical Issues	9
79-377	Food, Culture, and Power: A History of Eating	9
80-135	Introduction to Political Philosophy	9
80-136	Social Structure, Public Policy & Ethics	9
80-226	Revolutions in Science	9
80-235	Political Philosophy	9
80-245	Medical Ethics	9
80-276	Philosophy of Religion	9
80-341	Computers, Society and Ethics	9
80-344	Management, Environment, and Ethics	9
84-104	Decision Processes in American Political Institutions	9
84-210	Comparative Political Systems	9
84-275	Comparative Politics	9
84-310	International Political Economy and Organizations	9
84-320	Domestic Politics and International Affairs	9
84-321	Autocrats and Democrats	9
84-322	Attitudes, the Media, and Conflict in International Relations	9
88-110	Experiments with Economic Principles	9
99-238	Materials, Energy and Environment	9
79-268	World War I: The Twentieth Century's First Catastrophe	9

Category 3: Cultural Analysis

57-173	Survey of Western Music History	9
57-209	The Beatles	9
76-227	Comedy	9

70-342	Managing Across Cultures	9
76-232	Introduction to African American Literature	9
76-239	Introduction to Film Studies	9
76-241	Introduction to Gender Studies	9
79-104	Global Histories	9
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-225	West African History in Film	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-235	Caribbean Cultures	9
79-240	The Development of American Culture	9
79-241	African American History: Africa to the Civil War-American History I	9
79-242	African American History: Reconstruction to the Present-American History II	9
79-255	Irish History	6
79-261	Chinese Culture and Society	9
79-265	Russian History: From the First to the Last Tsar	9
79-281	Introduction to Religion	9
79-297	Dilemmas and Controversies in Anthropology	9
79-307	Religion and Politics in the Middle East	9
79-310	From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present	9
79-345	The Roots of Rock and Roll	9
79-350	Early Christianity	9
80-100	Introduction to Philosophy	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-261	Empiricism and Rationalism	9
80-276	Philosophy of Religion	9
82-xxx	Any Course Offered by Modern Languages	

C. Elective Course Requirements (36 units)

Complete non-technical courses totaling 36 units from DC, CFA, and Tepper. These can include language courses and music courses, for instance. In this category, you have the freedom to design how you want to structure your remaining general education requirements. For example, you can use these electives to build a depth sequence of 2-4 courses in a particular area or you can take courses from different areas or some combination of each.

Check our web site for courses from DC, CFA, and Tepper that may NOT be used (<http://www.cmu.edu/mcs/undergrad/advising/hss-finearts/deletions.html>) to satisfy these requirements because they are too technical in nature, plus a list of courses in other colleges (including SCS, CIT, Tepper, and Heinz College) that do satisfy these requirements (<http://www.cmu.edu/mcs/undergrad/advising/hss-finearts/additions.html>).

For Students Entering in the Fall of 2015 and Beyond

Carnegie Mellon's Mellon College of Science (MCS) has a distinguished record of educating leaders in science and technology. Science education in the 21st Century demands educational experiences that are much broader than the traditional preparation of a scholar in a chosen field of science. We want our MCS graduates to be **scholars** who are deeply trained in their discipline(s), and also **professionals** adept at communicating to broad audiences, accustomed to working in diverse, multidisciplinary teams, and keenly aware of the global context of their work. We want them to be **citizens** who are actively involved and globally engaged, and to grow as **persons** with a sense of wellness and balance.

With these ambitions in mind, we have set forth fifteen (15) outcomes that all MCS undergraduate students should complete in their time at Carnegie Mellon. Upon graduation, MCS students should be able to:

1. Apply foundational and advanced mathematical and scientific knowledge in a chosen field of study appropriately and fluently to solve

- complex problems, to integrate concepts across disciplines, and to adapt their knowledge to new situations.
- Critically assess their current state of knowledge and expertise and acquire new knowledge in pursuit of both specific scientific goals and new intellectual interests broadly throughout their lifetime.
 - Communicate effectively via oral, visual, and written formats with an understanding of the perspectives and expectations of diverse audiences, including those within their chosen discipline, outside that discipline (but within STEM), and non-scientists.
 - Participate effectively in multidisciplinary research and/or other teams pursuing a shared vision while optimizing team outcomes.
 - Use the appropriate tools and required media literacy to acquire, assess, and analyze data and information from diverse sources.
 - Recognize and explain the importance of at least one current research topic in a STEM field outside of their major.
 - Recognize and explain the similarities and differences in analyzing/ approaching problems, including in technical and non-technical fields other than their major.
 - Demonstrate knowledge of the arts, humanities, and social sciences.
 - Recognize the interplay of science, society, public policy, business, and economics.
 - Identify global examples of the reciprocal relationships among science, technology, political forces, societal contexts, and environmental issues.
 - Describe multiple similarities and differences between one's own culture and that of others.
 - Engage in recursive, reflective processes to assess their own levels of physical, emotional, and social wellness and then to choose activities that promote these aspects of wellness.
 - Engage in recursive, reflective processes to balance multiple endeavors by setting priorities and managing time in academic, meta-curricular, and personal dimensions.
 - Recognize ethical issues and appreciate the complexities of interrelationships among them, and the use of information in ethical and legal manners.
 - Articulate how one's own developing skills in science and technology can be increasingly used in constructive community service or engagement that recognizes the potential impact on local and global issues, including environmental impact and sustainability.

Students pursuing any MCS bachelor's degree will fulfill these outcomes through their primary MCS major and by completing the following technical and nontechnical breadth requirements prior to graduation.

Technical Breadth Requirements

As a 21st Century practicing scientist or mathematician, our graduates will work with others from a variety of technical backgrounds. Therefore, all of our students will be broadly trained within the technical fields of science and math. Students will fulfill this training by completing four (4) technical courses in the Science, Technology, Engineering, and/or Mathematics (STEM) fields at Carnegie Mellon University.

A student must take at least 9 units, outside of their primary major Department, from each of 4 categories listed below. These may include pre-requisite courses or courses required by their major Department but must be outside their home Department. AP/IB/Cambridge credit may not be used to fulfill these requirements. At least 3 of these courses must be taken in their first year. The categories are:

A. Life Sciences

(Refer to your specific department for how this category should be fulfilled. Some courses have pre-requisites that can be satisfied by AP, IB, Cambridge A Level Exams. Please check the prerequisites requirements as necessary.)

LIFE SCIENCES

02-223	Personalized Medicine: Understanding Your Own Genome	9
02-261	Quantitative Cell and Molecular Biology Laboratory	9
03-115	Phage Genomics Research	6
03-116	Phage Genomics Research	6
03-121	Modern Biology	9
03-124	Modern Biology Laboratory	9
03-125	Evolution	9
03-127	How Biological Experiments Work - A Project Course	9
03-161	Molecules to Mind	9

03-231	Biochemistry I	9
or 03-232	Biochemistry I	
03-250	Introduction to Computational Biology	12
03-260	Neurobiology of Disease	9
42-101	Introduction to Biomedical Engineering	12
42-202	Physiology	9
85-219	Biological Foundations of Behavior	9

B. Physical Sciences

(Refer to your specific department for how this category should be fulfilled. Some courses have pre-requisites that can be satisfied by AP, IB, Cambridge A Level Exams. Please check the prerequisites requirements as necessary.)

PHYSICAL SCIENCES

09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-107	Honors Chemistry: Fundamentals, Concepts and Applications	10
09-214	Physical Chemistry	9
09-217	Organic Chemistry I	9
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-348	Inorganic Chemistry	10
33-111	Physics I for Science Students	12
33-106	Physics I for Engineering Students	12
33-151	Matter and Interactions I	12
33-211	Physics III: Modern Essentials	10
33-224	Stars, Galaxies and the Universe	9
33-225	Quantum Physics and Structure of Matter	9

C. Mathematics, Statistics, and Computer Science

(Refer to your specific department for how this category should be fulfilled. Some courses have pre-requisites that can be satisfied by AP, IB, Cambridge A Level Exams. Please check the prerequisites requirements as necessary.)

MATH, STATS, and CS

02-201	Programming for Scientists	12
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-124	Calculus II for Biologists and Chemists	10
21-127	Concepts of Mathematics	10
21-128	Mathematical Concepts and Proofs	12
21-228	Discrete Mathematics	9
21-241	Matrices and Linear Transformations	10
or 21-240	Matrix Algebra with Applications	
or 21-242	Matrix Theory	
21-259	Calculus in Three Dimensions	9
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9
or 21-261	Introduction to Ordinary Differential Equations	
36-201	Statistical Reasoning and Practice	9
36-202	Statistical Methods	9
36-217	Probability Theory and Random Processes	9
36-220	Engineering Statistics and Quality Control	9
36-225	Introduction to Probability Theory	9
36-247	Statistics for Lab Sciences	9
36-309	Experimental Design for Behavioral and Social Sciences	9
15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10
15-150	Principles of Functional Programming	10
15-251	Great Theoretical Ideas in Computer Science	12

D. STEM Course

- All of the above courses
- Any Introductory engineering course from CIT

- A STEM course approved by an MCS advisor

Technical Breadth--Departmental Requirements

Some of the majors in MCS require certain courses from the technical breadth requirement that are necessary for either prerequisite knowledge in the major or scientific breadth. For each of the four majors in MCS the Technical Breadth Requirement is completed as follows. If these requirements are met by AP/IB/Cambridge A Level Exams, students can choose any course from the categories to fulfill the Technical Breadth Requirement.

Biological Sciences

1. Life Sciences: any courses in this category except for the 03-XXX courses
2. Physical Sciences: 09-105, 09-106, 33-121 and 33-122
3. Math/CS/Stats: 21-120 and (21-122 or 21-124)
4. STEM Elective: will be filled by courses above or any STEM course from the approved list.

Chemistry

1. Life Sciences: 03-121 or 03-231 or 03-232
2. Physical Sciences: 33-121 and 33-122
3. Math/CS/Stats: 21-120 and (21-122 or 21-124)
4. STEM Elective: will be filled by courses above or any STEM course from the approved list.

Mathematical Sciences

1. Life Sciences: any courses in this category
2. Physical Sciences: any course in this category
3. Math/CS/Stats: any course in this category except for the 21-XXX courses and 36-201 and 36-202
4. STEM Elective: any STEM course from the approved list.

Physics

1. Life Sciences: 03-121
2. Physical Sciences: 09-105
3. Math/CS/Stats: 21-120, 21-122, 21-259
4. STEM Elective: will be fulfilled by courses above or any STEM course from the approved list.

Nontechnical Breadth Requirements

MCS aspires for all of our undergraduates to leave our campus with a strong sense of personal integrity, social responsibility, ethics, working with diverse others, global engagement, and personal health and well-being. The following non-technical breadth requirements will require students to develop a personalized plan for their course selection and meta-curricular participation to maximize their CMU experience. Our graduates will be well trained to be life-long and life-wide learners that will lead the scientific community and the world at large.

All candidates for MCS bachelor's degrees must complete the following non-technical breadth requirements:

A. The following three courses must be taken in the first year:

38-101	EUREKA!: Discovery and Its Impact	6
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
or 99-102	Computing @ Carnegie Mellon	

B. The following course must be taken in the Spring of the junior year:

38-301 MCS Junior Seminar

C. ENGAGE Courses:

The ENGAGE courses are self-directed learning opportunities (using the MyCORE online platform) designed to enhance students' engagement with wellness, the arts and community service. Please see the course description for information on when these courses should be taken:

ENGAGE COURSES		
38-110	ENGAGE in Service	1
38-220	ENGAGE in the Arts	2
38-230	ENGAGE in Wellness: Looking Inward	1
38-330	ENGAGE in Wellness: Looking Outward	1
38-430	ENGAGE in Wellness: Looking Forward	1

D. Cultural/Global Understanding Course:

Cultural or global understanding course(s) may be taken at any time. Nine (9) or more units from the following group of courses will fulfill this requirement. Any student who finds an appropriate Carnegie Mellon course not on the list below that might fulfill this requirement should contact their academic advisor to review the course description to determine if it can be substituted. Cultural and global understanding courses that are taken while studying abroad can be used to fulfill this category. In addition, transfer courses will also be considered for this category. However, this course requirement *cannot* be satisfied with AP/IB/Cambridge exam credit.

CULTURAL/GLOBAL UNDERSTANDING

57-173	Survey of Western Music History	9
57-209	The Beatles	9
57-306	World Music	6
70-342	Managing Across Cultures	9
73-331	Political Economy of Inequality and Redistribution	9
76-221	Books You Should Have Read By Now	9
76-227	Comedy	9
76-232	Introduction to African American Literature	9
76-239	Introduction to Film Studies	9
76-241	Introduction to Gender Studies	9
76-386	Language & Culture	9
79-104	Global Histories	9
79-201	Introduction to Anthropology	9
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-207	Development of European Culture	9
79-221	Development and Democracy in Latin America	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-240	The Development of American Culture	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-255	Irish History	6
79-261	Chinese Culture and Society	9
79-265	Russian History: From the First to the Last Tsar	9
79-266	Russian History: From Communism to Capitalism	9
79-275	Introduction to Global Studies	9
79-281	Introduction to Religion	9
79-297	Dilemmas and Controversies in Anthropology	9
79-307	Religion and Politics in the Middle East	9
79-345	The Roots of Rock and Roll	9
79-349	The Holocaust in Historical Perspective	9
79-350	Early Christianity	9
79-355	Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective	9
79-357	History of Black American Music	6
79-377	Food, Culture, and Power: A History of Eating	9
80-100	Introduction to Philosophy	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-276	Philosophy of Religion	9
82-xxx	Any course from Modern Languages	
99-241	Revolutions of Circularity	9
99-3xx	Any of the Country Today courses	

E. Arts, Humanities, and Social Sciences Courses

To fulfill this requirement, students must complete a minimum of four (4) nontechnical courses totaling at least 36 units in the College of Fine Arts, the Tepper School of Business and/or the Dietrich College for Humanities and Social Sciences. A maximum of 18 units of these units may be fulfilled via AP/IB/Cambridge exam credit. Courses counted toward the Cultural/Global Understanding requirement, and 76-101, do not count toward this requirement.

Check our web site for courses from DC, CFA, and Tepper that may NOT be used (<http://www.cmu.edu/mcs/undergrad/advising/hss-finearts/deletions.html>) to satisfy this requirement because they are too technical in nature, plus a list of courses in other colleges (including SCS, CIT, Tepper, and Heinz College) that do satisfy (<http://www.cmu.edu/mcs/undergrad/advising/hss-finearts/additions.html>) this requirement.

For students entering in the Fall of 2015 and beyond, the following requirements apply to all MCS bachelor's degrees:

1. Students must complete a minimum of 360 units.
2. The four courses required for the Technical Breadth category can be completed at Carnegie Mellon or via transfer credit.
3. AP/IB/Cambridge exam credit cannot be used to fulfill the Cultural/Global Requirement. Cultural and global understanding courses that are taken while studying abroad can be used to satisfy this requirement. In addition transfer courses will also be considered for this category.
4. For the Arts, Humanities and Social Sciences Electives requirement, students must complete a minimum of four courses totaling at least 36 units with a maximum of 18 units from AP/IB/Cambridge exam credit.

Intercollege Programs

MCS participates in two intercollege programs, the Bachelor of Science and Arts Degree program and the Science and Humanities Scholars program. Enrollment for the Science and Humanities program is by invitation only for incoming first-year students, and by application for current students.

Bachelor of Science and Arts Degree Program (BSA)

Students in the Bachelor of Science and Arts Degree program are jointly admitted to MCS and the College of Fine Arts (CFA). This is a degree program for students who are naturally gifted in both the arts and the sciences, and allows for the combining of talents in these areas.

More details can be found at <http://coursecatalog.web.cmu.edu/servicesandoptions/intercollegeprograms/bxaintercollege/>

Science and Humanities Scholars Program (SHS)

Students in the Science and Humanities Scholars Program (SHS) are jointly admitted to MCS and the Dietrich College of Humanities and Social Sciences (DC). Participants in this program follow a special general education core, but have the flexibility to choose a primary major in either of the two colleges. More detail can be found at <http://coursecatalog.web.cmu.edu/servicesandoptions/intercollegeprograms/>

Applying Your Education Through Research

An important feature of education in MCS is the opportunity for undergraduate research experience. This experience may be arranged as a course taken for credit or occasionally as a part-time job. Our web site (www.cmu.edu/mcs/) offers a range of useful information including links to faculty research areas, links to undergraduate research programs at other institutions, and ideas on how to get involved. Because of the strong research base of MCS, undergraduate research positions offer an exciting opportunity to apply your theoretical training to participate in the discovery of new knowledge.

Students can earn MCS Research Honors for significant research accomplishments; see the policy outlined below for the requirements.

Mellon College of Science Research Honors

Undergraduates in the Mellon College of Science will be awarded MCS College Honors at the completion of their degree if they have met one of these requirements:

1. Successfully completed the Honors BS/MS program in the Department of Chemistry or Department of Mathematical Sciences.
2. Successfully completed the departmental honors program in the Department of Biological Sciences or the Department of Chemistry.
3. Earned a cumulative grade point average of 3.20 or higher and carried out significant research. Typically, this would consist of an academic project carried out for at least two semesters. However, a single project that spans a summer and a semester or that the research mentor

deems to be significant and sustained, even if the student worked for pay rather than credit, will be allowed. In addition, some form of public dissemination of this research, which has been approved by the Associate Dean of MCS, such as a peer reviewed publication, research thesis, or presentation at an external scientific meeting is required. The Meeting of the Minds by itself is not sufficient and participation in a preapproved judged competition, such as Sigma Xi, is necessary.

Final approval of nominations for MCS Honors will come from the Dean of MCS and the Associate Dean for Undergraduate Affairs.

Research Centers

The Mellon College of Science is home to a number of innovative research centers. These centers are particularly strong because of the interdisciplinary collaboration of their scientists. This interdisciplinary research brings international prestige to the college. Many students conduct undergraduate research with one of these centers.

The Bruce and Astrid McWilliams Center for Cosmology joins research efforts in astrophysics and particle physics and partners with computer science, statistics, and other disciplines to unravel the mysteries of the universe.

The Center of Atmospheric Particle Study's goal is to be the world leader in science, engineering, and policy covering the full role of fine particulate matter in the atmosphere. Our goal in research is to advance the state of knowledge across this spectrum substantially, to provide both policy-relevant research, and to participate directly and actively in the evolution of environmental policy related to particulate matter.

The Center for Computational Finance's mission is to improve the interaction between academic research and the finance industry.

The Center for Macromolecular Engineering's goals are to enhance the benefits of polymer science to society by developing new methods to prepare advanced polymer materials, train and develop tomorrow's scientists, and transfer technology to industry.

The Center of Nano-enabled Device and Energy Technologies' mission is to work on real-world problems that can be solved potentially with appropriate nano-enabled technologies.

The Center for the Neural Basis of Cognition is a joint program between Carnegie Mellon University and the University of Pittsburgh. It synthesizes the disciplines of basic and clinical neuroscience, cognitive psychology, and computer science, combining neurobiological, behavioral, computational, and brain imaging methods.

The Center for Nonlinear Analysis was established in 1991. A special focus for applications emphasizes new and innovative methods to study contemporary issues in materials science. The center has created a vigorous environment for collaboration among mathematical and allied scientists.

The Center for Nucleic Acids Science and Technology is a community of Carnegie Mellon scientists and engineers unified by interests in the chemistry, biology, and physics of DNA, RNA, and PNA (peptide nucleic acid).

The Institute for Green Science has been established as a research, education, and development center in which a holistic approach to sustainability science is being developed. The focus of the institute is in three areas: renewable energy technologies, chemical feedstocks, and benign alternatives to polluting technologies.

The Molecular Biosensor and Imaging Center uses an interdisciplinary approach to develop reagents, microscopes, and imaging tools and applies them to the investigation of fundamental problems in biology and biotechnology.

The Pittsburgh NMR Center for Biomedical Research is a joint program between Carnegie Mellon University and the University of Pittsburgh. It is supported as a Biotechnology Resource Center by the National Institutes of Health.

The Pittsburgh Supercomputing Center provides information on advanced scientific computing for engineering and research.

The Computational Biology Department seeks to realize the potential of machine learning for expanding our understanding of complex biological systems. A primary goal of the Center is to develop computational tools that will enable automated creation of detailed, predictive models of biological processes, including automated experiment design and data acquisition.

Academic Standards

Academic Actions

MCS Dean's List

Each semester MCS recognizes those students with outstanding academic records by naming them to the Dean's List. The criteria for such recognition are as follows:

Dean's List

The student must earn a quality point average of at least 3.5 while completing a minimum of 36 factorable units and earning no incomplete grades.

Dean's List High Honors

The student must earn a quality point average of at least 3.75 while completing a minimum of 36 factorable units and earning no incomplete grades.

Probation, Suspension, and Drop

In the first year, quality point averages below 1.75 in either semester invoke an academic action. For all subsequent semesters an academic action will be taken if the semester QPA or the cumulative QPA (excluding the first year) is below 2.00.

The progression below between probation, suspension, and drop is typical. However, for example, in unusual circumstances, MCS College Council may choose to suspend or drop a student without prior probation.

Probation

The action of probation will be taken if:

- One semester of the first year is below 1.75 QPA.
- The semester QPA of a student in good standing beyond the first year falls below 2.00. The term of probation is one semester as a full-time student. First-year students are no longer on probation at the end of the second semester if their semester QPA is 1.75 or above.

A student is occasionally continued on probation who has had one semester on probation and is not yet meeting minimum requirements but whose record indicates that the standards are likely to be met at the end of the next semester of study.

Suspension

A student who does not meet minimum standards at the end of one semester of probation will be suspended.

A first-year student will be suspended if the QPA from each semester is below 1.75.

A student in the third or subsequent semester of study will be suspended if the semester factor or the cumulative factor (excluding the first year) is below 2.00 for two consecutive semesters.

The minimum period of suspension is one academic year (two semesters). At the end of that period a student may return to school on probation by:

- Receiving permission in writing from the Associate Dean of MCS.
- Completing a Return from Leave form from Enrollment Services.
- Providing transcripts and clearance forms if the student has been in a degree program at another college or university, even though academic credit earned will not transfer to Carnegie Mellon unless prior approval has been granted by the Associate Dean.

Employment within the university in non-student jobs is possible for students on academic suspension, subject to the hiring criteria of the hiring department. However, a student on academic suspension wishing to accept a job on campus must speak with the Associate Dean of the student's college to ensure that the employment will not constitute a violation of the terms of suspension. The Associate Dean will generally allow such employment, in consultation with the Dean of Student Affairs. One employment benefit not available to students on academic suspension who accept a full-time job with the University is the option to take courses through tuition remission. The option to take courses becomes available only after the academic suspension is over.

Drop

This is a permanent severance from the Mellon College of Science. Students are dropped when it seems clear that they will never be able to meet

minimum standards. A student who has been suspended and who fails to meet minimum standards after returning to school is dropped.

A student who has been academically dropped or academically suspended and who is not employed by the University must absent themselves from campus and is, for the term of the suspension, barred from all activities and affiliations that stem from one's status as an enrolled student. These include registering or enrolling for courses, sitting in on classes, living in residence halls or Greek houses, membership and participation in student activities, and employment in student jobs. (NOTE: Exceptions to the restriction from student jobs for students on academic suspension will in general be granted for summer employment if the position was accepted prior to the decision to suspend.)

Transfer into MCS Departments

Undergraduate students admitted to MCS can choose to pursue any major within MCS. This choice must be made prior to the first semester of the sophomore year (normally during the second semester of the first year) and does not require approval by any department.

Undergraduate students admitted to colleges other than MCS and wishing to transfer into an MCS department during their first year should consult with the MCS Associate Dean for Undergraduate Affairs. Students may submit an internal transfer request no earlier than mid-term of the spring semester of the first year. Potential transfer students must also have successfully taken 21-120 Differential and Integral Calculus and, depending on major choice, one of the following: 03-121 Modern Biology, 09-105 Introduction to Modern Chemistry I, or 33-111 Physics I for Science Students.

MCS undergraduate students beyond the first year wishing to transfer into another MCS department may do so if they are not on academic probation and if there is room in the department of their choice. If the demand for any department exceeds the space available, then the department will admit students based on a comparative evaluation of all applicants at the end of each semester, up to the limit of available space.

Undergraduate students not in MCS and wishing to transfer into a department in MCS beyond the first year will be considered for transfer on a space available/academic performance basis. An MCS department may refuse a transfer to a non-MCS student if there are space restrictions and/or if the student's chance for success is determined to be questionable based on past academic performance.

Procedure for transfer of students from another university into an MCS department:

A student first applies through the Office of Admission. If the Office of Admission believes the applicant is acceptable, the student's record is sent to the appropriate department for evaluation and a decision on acceptance. The MCS department head has the right to refuse to accept the student if there are space restrictions and/or if the student's chance for success in the MCS department is determined to be questionable based on past academic performance.

Graduation Requirements

To be eligible to graduate, undergraduate students must complete all course requirements for their program with a cumulative Quality Point Average of at least 2.0 for all courses taken. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. Some programs may have additional QPA requirements in order to graduate. Students are encouraged to confirm all graduation requirements with their academic advisor.

A minimum of 360 units must be completed. This will include the MCS Science Core Courses, humanities or fine arts requirements and all departmental course requirements.

Students will be required to meet the residency requirement and to have met all financial obligations to the university before being awarded a degree. The residency requirement is detailed in the Academic Regulations section of the catalog.

A student may seek permission to modify graduation requirements by petition to the MCS College Council.

Graduation Honors

There are two types of honors awarded at graduation.

University Honors

University Honors are automatically awarded to students who have earned a cumulative Q.P.A. of 3.5 or better after seven semesters.

College Research Honors

Please see the section “Mellon College of Science Research Honors” for information on how to qualify for College Research Honors.

Faculty

WILLIAM ALBA, Director of Science and Humanities Scholars Program.

MAGGIE BRAUN, Director of Core Education.

JASON D'ANTONIO, Director of Health Professions Program.

ERIC W. GROTZINGER, Associate Dean for Undergraduate Affairs.

JOHN F. HANNON, Director of Integrative Learning.

CURTIS MEYER, Associate Dean for Faculty and Graduate Affairs.

Administration

CHARLOTTE BARTOSH, Interdisciplinary Laboratory Research Technician.

VERONICA PEET, Senior Academic Advisor.

TARA PRIMIERO, Administrative Coordinator.

MAY SIMAAN, Administrative Coordinator.

Minors Offered by the Mellon College of Science

The Mellon College of Science offers several minors to students interested in broadening their scientific training or acquiring a level of expertise in a particular scientific field. The intercollege minors described below are designed to supplement your degree in science; the departmental minors offer you a means of exploring another field and are open to students throughout the university.

Intercollege Minors

Please see the descriptions below.

- Environmental Science
- Health Care Policy and Management
- Scientific Computing

Departmental Minors in the Mellon College of Science

For descriptions, please see the departmental sections which follow.

- Biological Sciences
- Chemistry
- Computational Finance
- Discrete Mathematics and Logic
- Mathematical Sciences
- Physics

Minor in Environmental Science

Advisor: Eric Grotzinger

The primary mission of the environmental sciences minor is to prepare students in the Mellon College of Science for careers or postgraduate education in the diverse fields of environmental science. We feel strongly that these endeavors must be grounded in strong fundamental science; consequently, the program extends majors in the Mellon College of Science.

We also award minors to students from other colleges, provided that they can build a course of study with sufficient scientific rigor to meet the standards of the program.

As a capstone program, the minor is built around advanced courses that extend as well as broaden the specialized education associated with the major programs. Environmental sciences are highly interdisciplinary in nature, and while it is necessary that students have an exposure to introductory courses in several of these disciplines, it is by no means sufficient; in-depth knowledge is required. We encourage all students to pursue generally broad studies, including subjects that encompass human interactions with the environment, and will provide guidance to all students interested in the area. We encourage those students who intend to devote focused attention to environmental sciences to pursue this minor.

Environmental Sciences are broadly defined as pursuits designed to develop fundamental understanding of the natural environment and human interactions with the environment. Research problems are frequently motivated by perceived problems (air, water and soil pollution, reduction in biodiversity, global climate change, etc...), but inevitably extend to the fundamental mechanisms underlying these phenomena. Research can be highly specialized (focusing for example on the biochemistry of a particular enzyme or the synthesis of a particular catalyst) or highly general (focusing for example on the complex, nonlinear interactions of populations on complex ecosystems). Our program is designed to ensure that students of the field are conversant with questions on all of these scales, from the microscopic to the global.

Required Courses:

Science Requirements (27 units)

09-217	Organic Chemistry I	9-10
or 09-219	Modern Organic Chemistry	
09-218	Organic Chemistry II	9-10
or 09-220	Modern Organic Chemistry II	
03-231/232	Biochemistry I	9

Laboratory Requirement (12 units)

09-221	Laboratory I: Introduction to Chemical Analysis	12
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Statistics Requirement (9 units)

36-217	Probability Theory and Random Processes	9
36-225	Introduction to Probability Theory	9
36-247	Statistics for Lab Sciences	9

Additional Course Requirements:

Complete one course from each of the following groups (substitutions can be made with the approval of the Environmental Science Advisor).

Note: Courses taken in these categories cannot also be counted toward requirements for a primary major.

Science (Mechanism)

03-442	Molecular Biology	9
09-510	Chemistry and Sustainability	9
09-520	Global Atmospheric Chemistry: Fundamentals and Data Analysis Methods	9
06-630	Atmospheric Chemistry, Air Pollution and Global Change	12
xx-xxx	Course credit may be assigned for research, fieldwork, or coursework performed outside of CMU at the discretion of the minor advisor.	

Engineering (Process)

12-100	Introduction to Civil and Environmental Engineering	12
12-201	Geology	9
12-351	Environmental Engineering	9
12-651	Air Quality Engineering	9
19-440	Combustion and Air Pollution Control	9

Policy

19-424	Energy and the Environment	9
19-448	Science, Technology & Ethics	9
73-148	Environmental Economics	9
73-358	Economics of the Environment and Natural Resources	9
79-372	Perspectives on the Urban Environment	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
80-344	Management, Environment, and Ethics	9
99-238	Materials, Energy and Environment	9

Minor in Health Care Policy and Management

Sponsored by:

H. John Heinz III College
Dietrich College of Humanities and Social Sciences
Mellon College of Science

Faculty Advisors:

Jason D'Antonio, Mellon College of Science
James F. Jordan, H. John Heinz III College

The face of health care is changing. The practice of medicine is being fundamentally altered by the forces of change in public policy, health care organizations and in the industry as a whole. The role of individual professionals in this industry is changing as rapidly as the industry itself. Traditional career paths have disappeared overnight to be replaced by new opportunities that require new skills. New organizations are placing new demands on their professional and medical staffs. The criteria of efficiency and financial stability are entering the domains of diagnosis and treatment.

This minor is designed to provide students considering a career in the health professions with an understanding of how these changes are likely to affect their careers. Students will become familiar with the critical policy and management issues and will begin to learn to operate effectively in the emerging health care environment. The curriculum combines economic, organizational, managerial, historical and psychological perspectives on

these issues to provide a foundation for a deepened understanding of the changing structure of health care organizations and policy.

Curriculum 60 units minimum

Seven courses (a minimum of 60 units) are required to complete this minor. Entry into the minor requires completion of 73-100 Principles of Economics or 88-220 Policy Analysis I or the equivalent by approval.

Required Courses 39 units

Students are required to take the following courses.

79-330	Medicine and Society	9
90-836	Health Systems	6
90-861	Health Policy	6
94-705	Health Economics	12

Elective Courses 27 units

Complete a minimum of 27 units.

Heinz College Courses

90-708	Healthcare Ethics	6
90-721	Healthcare Management	6
90-818	Health Care Quality & Performance Improvement	6
90-830	Introduction to Financial Management of Health Care	6
90-831	Advanced Financial Management of Health Care	6
90-832	Health Law	6
90-863	Health Policy II	6
94-706	Healthcare Information Systems	12

Humanities and Social Sciences Courses (9 units each)

76-494	Healthcare Communications	9
79-383	Epidemics, Disease, and Public Health	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
85-241	Social Psychology	9
85-442	Health Psychology	9
85-446	Psychology of Gender	9

Please note that some of these courses have prerequisites that will not count toward the completion of the requirements for this minor.

Minor in Scientific Computing

Advisor: Eric Grotzinger

Sometimes called "computational science," scientific computing is the application of high-performance computers and modern computational technologies to problems in the sciences and engineering. Research in this area is inherently multidisciplinary, requiring strong ties with a scientific discipline.

MCS students can easily build on their scientific training with this applied computational program. The curriculum consists of five areas of concentration, which span the natural sciences, mathematics, programming and research. The curriculum is structured to allow flexibility in choosing courses that meet students' particular interests or best compliment their major. The minor is also a natural choice for students majoring in any technical area.

Required Courses

Students must meet the requirements of the following categories:

A. Non-Introductory Science Requirement (9-12 units)

Complete 1 course from Biological Sciences, Chemistry, or Physics at the 200 level or higher, excluding those courses listed below as part of the requirements of the minor. Courses with a significant science component from other colleges may be substituted with approval from the program administrator.

B. Computational Science Requirement (18-24 units)

Complete 2 of the following courses:

03-250	Introduction to Computational Biology	12
03-511	Computational Molecular Biology and Genomics	9
09-560	Computational Chemistry	12
15-386	Neural Computation	9
33-241	Introduction to Computational Physics	9

C. Computational Methods Requirement (9 units)

Complete one of the following courses from outside of your home department.

21-320	Symbolic Programming Methods	9
21-369	Numerical Methods	9
33-232	Mathematical Methods of Physics	10
33-456	Advanced Computational Physics	9
36-410	Introduction to Probability Modeling	9

D. Applied Scientific Computing Research Project(s) (9 units)

Complete one approved research project in an area of applied scientific computing. In some cases, this research could be replaced with 9 units of an approved project-based course in advanced scientific computing. The administrator of the minor will maintain a list of appropriate courses. Under special circumstances summer research may count toward this requirement, although it cannot be counted toward the units required for graduation.

E. Complete any additional course from category C or D (9 units)

Department of Biological Sciences

Aaron P. Mitchell, Interim Department Head
Becki Campanaro, Assistant Department Head for Undergraduate Affairs
Undergraduate Office: Doherty Hall 1321
<http://www.cmu.edu/bio>

A major revolution is occurring in the field of biological sciences. Biology is undergoing unprecedented technological advances in biochemistry, biophysics, cell biology, genetics, molecular biology, developmental biology, neuroscience and computational biology. Carnegie Mellon's Department of Biological Sciences is nationally recognized as one of the outstanding departments in these areas. Advances in basic research are already being used to solve problems, not only in medicine and public health, but also in areas such as agriculture, forestry, mining, energy, and in industrial and pharmaceutical manufacturing processes. The department provides its students with an education that has both intellectual breadth and depth of exposure to modern research biology. This education can be used to gain employment immediately after graduation in government, industry or academic research laboratories, or to pursue graduate studies in a variety of areas such as science, medicine, public health, law, or business. A degree in biological sciences provides excellent preparation for medical school or other graduate programs in the health professions. These students are aided by the Carnegie Mellon Health Professions Program (HPP), an advisory and resource service for all Carnegie Mellon students who are considering careers in the health care field. (See the HPP (<http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#healthprofessionsprogram>) section in this catalog or www.cmu.edu/hpp for more information.)

The department offers a Bachelor of Science (B.S.) degree in Biological Sciences. This program has a distinctive core curriculum that provides a foundation in biology, chemistry, computer science, mathematics, and physics. In addition to the core courses, the program includes six biology electives, five free electives as well as eight humanities, social science and fine arts electives. With these electives, students can shape a degree program according to their own interests and career goals. For students who have an interest in a particular field of biology and wish to have a specialized focus, the department offers options in biochemistry, biophysics, cell biology, computational biology, developmental biology, genetics, molecular biology and neuroscience that provide the relevant training in each area. The options are especially recommended for students who are considering graduate school in one of these areas. The B.S. degrees in Biological Sciences/Neuroscience Track and Neuroscience are available to those students who wish to pursue an in-depth study of neuroscience.

In this exciting era that includes the influence of biology and the life sciences on many fields from medicine to law, the in-depth exposure to multiple disciplines provides opportunities for students to prepare for involvement at the forefront of emerging new fields, markets, and policy changes. The Department of Biological Sciences at Carnegie Mellon is working at these new interfaces through interdisciplinary research and educational programs. Innovative interdisciplinary degrees which are offered by the department include the inter-college B.S. degrees in Computational Biology and Neuroscience as well as an unified B.S. degree in Biological Sciences and Psychology. Students also explore interdisciplinary studies through the Science and Humanities Scholars program, or pursue interests at the interface between the arts and sciences through the Bachelor of Science and Arts (B.S.A.) degree program combining biological sciences with a discipline in the College of Fine Arts. A stand-alone Bachelor of Arts (B.A.) degree is available for students who wish to expand their educational training into other fields. Many students choose to broaden their education by pursuing minors and additional majors in disciplines throughout the university, not just within the Mellon College of Science.

One of the most important features of the Department of Biological Sciences is the opportunity for undergraduate students to interact with faculty. Providing a solid foundation to scientific practice is critical; therefore, the department offers first-year students a variety of inquiry-based, hands-on courses that incorporate a wide range of topics and interests within Biological Sciences. These courses kick-start the transformation of science students to scientists. We encourage our students to get to know their faculty through one of these courses, or through mentored, independent research projects in the faculty laboratories. Our faculty members are prominent research scientists who also teach beginning and advanced courses. The upper level teaching laboratories are located in the same building as the faculty research laboratories and share scientific equipment. We encourage students to make themselves aware of the research areas of the faculty and to develop research projects with faculty. While such research is usually most important in the senior year, it may begin earlier in a student's undergraduate training. The department has an Honors Program in Research Biology to facilitate a more intensive involvement in research

for eligible students. During the past four years, more than 80 percent of the undergraduate biology majors have worked with faculty on their research and, in some cases, have been co-authors of research papers and have given presentations at national meetings.

As of the fall of 2011, the Department of Biological Sciences offers B.S. degrees in Biological Sciences as well as Computational Biology at Carnegie Mellon University in Doha, Qatar. Students enrolled in either of these degree programs will also complete the requirements outlined below. However, a limited number of required courses for the CMU-Qatar program are offered through a collaboration with the Weill Cornell Medical College in Qatar. For a listing of how the degree requirements are fulfilled for students enrolled in Doha, please consult the CMU-Qatar website (<https://www.qatar.cmu.edu/curriculum-bs>).

B.S. Biological Sciences

The Bachelor of Science (B.S.) in Biological Sciences is built around a core program and elective units as detailed in the following section.

Degree Requirements:

Biological Sciences	Units
03-121 Modern Biology	9
or 03-151 Honors Modern Biology	
03-231 Biochemistry I	9
03-240 Cell Biology	9
03-201/202 Undergraduate Colloquium for Sophomores	2
03-250 Introduction to Computational Biology	12
or 03-251 AND 03-252	
03-330 Genetics	9
03-343 Experimental Techniques in Molecular Biology	12
03-344 Experimental Biochemistry	12
or 03-345 Experimental Cell and Developmental Biology	
or 03-346 Experimental Neuroscience	
03-411 Topics in Research	1
03-412 Topics in Research	1
03-xxx Biological Sciences Electives ¹	54

Total Biology units 130

¹ Details on electives can be found in the "Biological Sciences Electives" section (see below).

Mathematics, Physics and Computer Science	Units
21-120 Differential and Integral Calculus	10
21-122 Integration and Approximation	10
or 21-124 Calculus II for Biologists and Chemists	
33-111 Physics I for Science Students	12
33-122 Physics II for Biological Sciences and Chemistry Students ³	9
02-201 Programming for Scientists ²	12
99-10x Computing at Carnegie Mellon	3

Total Science units 56

² 15-112 Fundamentals of Programming and Computer Science or 15-110 Principles of Computing can substitute for 02-201 towards the completion of the Programming course requirement.

³ 33-112 Physics II for Science Students may substitute for 33-122 Physics II for Biological Sciences and Chemistry Students towards completion of the Physics II requirement.

Chemistry	Units
09-105 Introduction to Modern Chemistry I	10
09-106 Modern Chemistry II	10
09-217 Organic Chemistry I	9
or 09-219 Modern Organic Chemistry	
09-218 Organic Chemistry II	9
or 09-220 Modern Organic Chemistry II	
09-221 Laboratory I: Introduction to Chemical Analysis	12

09-222	Laboratory II: Organic Synthesis and Analysis	12
Total Chemistry units		62
Elective Units		Units
Free Electives		39
MCS Nontechnical Breadth Requirements		72
Total Elective units		111

360 Minimum number of units required for degree:

MCS Technical Breadth Requirements

Majors entering CMU and majoring in Biological Sciences (or affiliated majors) in the Fall of 2015 or beyond will fulfill the MCS Technical Breadth requirements as follows:

1. Life Sciences: any courses in this category except for the 03-XXX courses (these can be counted as general bio electives towards your degree)
2. Physical Sciences: 09-105, 09-106, 33-121 and 33-122
3. Math/CS/Stats: 21-120 and (21-122 or 21-124)
4. STEM Elective: will be filled by courses above or any STEM course from the approved list.

Biological Sciences Electives

The following specifications apply to Biological Sciences electives:

- At least 18 units must be at the 03-3xx level or above, exclusive of 03-445 Undergraduate Research and 03-370 Principles of Biotechnology.
- Up to three interdisciplinary electives may count as biology electives.
- Up to 18 units of 03-445 Undergraduate Research may count as general biology electives; a maximum of 36 units can count for the minimum units required for graduation.
- Courses in biology taken through cross-registration or study abroad at another university may count as electives if prior permission is obtained from the Carnegie Mellon Department of Biological Sciences advisor.

Departmental Electives Group

03-115/116	Phage Genomics Research	6
03-124	Modern Biology Laboratory	9
03-125	Evolution	9
03-126	Cellular Response to the Environment	4
03-127	How Biological Experiments Work - A Project Course	9
03-161	Molecules to Mind	9
03-230	Intro to Mammalian Physiology	9
03-260	Neurobiology of Disease	9
03-326	Evolution of Regulatory Genomics	4.5
03-327	Phylogenetics	9
03-350	Developmental Biology	9
03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
03-364	Developmental Neuroscience	9
03-370	Principles of Biotechnology	9
03-390	Molecular and Cellular Immunology	9
03-391	Microbiology	9
03-392	Microbiology Laboratory	6
03-439	Introduction to Biophysics	9
03-442	Molecular Biology	9
03-445	Undergraduate Research	Var.
03-511	Computational Molecular Biology and Genomics	9
03-512	Computational Methods for Biological Modeling and Simulation	9
03-534	Biological Imaging and Fluorescence Spectroscopy	9
03-545	Honors Research	9
03-620	Techniques in Electron Microscopy	9
03-709	Applied Cell and Molecular Biology	12
03-711	Computational Molecular Biology and Genomics	12
03-712	Computational Methods for Biological Modeling and Simulation	12
03-713	Bioinformatics Data Integration Practicum	6

03-726	Evolution of Regulatory Genomics	6
03-727	Phylogenetics	12
03-730	Advanced Genetics	12
03-740	Advanced Biochemistry	12
03-741	Advanced Cell Biology	12
03-742	Molecular Biology	12
03-744	Membrane Trafficking	9
03-751	Advanced Developmental Biology and Human Health	12
03-762	Advanced Cellular Neuroscience	12
03-763	Advanced Systems Neuroscience	12
03-770	Principles of Biotechnology	12
03-791	Advanced Microbiology	12
03-871	Structural Biophysics	12

Interdisciplinary Electives Group

Up to three of the following courses may count as biology electives:

09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
09-521	Bioinorganic Chemistry	9
09-535	Applied topics in Macromolecular and Biophysical Techniques	9
15-211	Fundamental Data Structures and Algorithms	12
21-127	Concepts of Mathematics	10
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
36-201	Statistical Reasoning and Practice	9
36-247	Statistics for Lab Sciences	9
42-202	Physiology	9
85-219	Biological Foundations of Behavior	9

Options for the B.S. in Biological Sciences

Students who wish to specialize in a particular area of biology can do so through a set of departmentally defined options. A student who completes the required biology electives for any option can have up to two noted on his or her transcript. Options need not be declared. The elective courses required for each of the options are listed below.

Biochemistry OptionRequired Biology Electives:

03-740	Advanced Biochemistry	12
21-259	Calculus in Three Dimensions	9
or 21-260	Differential Equations	

Any ONE of the following courses:

09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
09-521	Bioinorganic Chemistry	9

Recommended Biology Electives:

03-442	Molecular Biology	9
03-534	Biological Imaging and Fluorescence Spectroscopy	9
03-439	Introduction to Biophysics	9
03-871	Structural Biophysics	12

Biophysics OptionRequired Biology Electives:

03-740	Advanced Biochemistry	12
03-439	Introduction to Biophysics	9
21-259	Calculus in Three Dimensions	9
or 21-260	Differential Equations	

Recommended Biology Electives:

03-534	Biological Imaging and Fluorescence Spectroscopy	9
03-871	Structural Biophysics	12

Cell Biology OptionRequired Biology Electives:

03-350	Developmental Biology	9
03-741	Advanced Cell Biology	12

Any ONE of the following courses:

03-362	Cellular Neuroscience	9
03-390	Molecular and Cellular Immunology	9

Computational Biology OptionRequired Biology Electives:

03-711	Computational Molecular Biology and Genomics	12
15-210	Parallel and Sequential Data Structures and Algorithms	12

Any ONE of the following courses:

36-247	Statistics for Lab Sciences	9
21-260	Differential Equations	9
21-241	Matrices and Linear Transformations	10

Recommended Biology Electives:

03-512	Computational Methods for Biological Modeling and Simulation	9
15-451	Algorithm Design and Analysis	12
09-560	Computational Chemistry	12

Developmental Biology OptionRequired Biology Electives:

03-350	Developmental Biology	9
03-442	Molecular Biology	9
03-751	Advanced Developmental Biology and Human Health	12

Recommended Biology Electives:

03-326	Evolution of Regulatory Genomics	4.5
03-741	Advanced Cell Biology	12

Genetics OptionRequired Biology Electives:

03-326	Evolution of Regulatory Genomics	4.5
03-327	Phylogenetics	9
03-442	Molecular Biology	9
03-730	Advanced Genetics ³	12

³ Minimum grade of B in 03-330 required.

Recommended Biology Electives:

03-391	Microbiology	9
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Molecular Biology OptionRequired Biology Electives:

03-442	Molecular Biology	9
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
03-726	Evolution of Regulatory Genomics	6
03-727	Phylogenetics	12

Recommended Biology Electives:

03-390	Molecular and Cellular Immunology	9
03-391	Microbiology	9
03-730	Advanced Genetics	12

Neuroscience OptionRequired Biology Electives:

03-362	Cellular Neuroscience ⁴	9
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03-363	Systems Neuroscience ⁴	9
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Any ONE of the following courses:

42-202	Physiology	9
03-260	Neurobiology of Disease	9
03-350	Developmental Biology	9
03-364	Developmental Neuroscience	9
03-534	Biological Imaging and Fluorescence Spectroscopy	9
85-219	Biological Foundations of Behavior	9

4. One of these courses must be completed at the Graduate Level (Complete either 03-762 or 03-763).

B.S. Biological Sciences/Neuroscience Track

The Bachelor of Science in Biological Sciences/Neuroscience Track provides an option for those Biological Sciences majors who are interested in an intensive curricular focus in neuroscience. The requirements of the Track are the same as those listed for the B.S. in Biological Sciences with the following changes to the biological sciences elective requirements:

Degree Requirements:

03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
03-761	Neural Plasticity ⁴	9

4 Substitutions for 03-761 Neural Plasticity may be approved by the Assistant Department Head on an individual basis. Suggested substitutions should be graduate level neuroscience courses.

Plus three of the following electives:

03-260	Neurobiology of Disease	9
03-350	Developmental Biology	9
03-364	Developmental Neuroscience	9
03-534	Biological Imaging and Fluorescence Spectroscopy	9
15-385	Introduction to Computer Vision	6
15-386	Neural Computation	9
42-202	Physiology	9
85-211	Cognitive Psychology	9
85-213	Human Information Processing and Artificial Intelligence	9
85-219	Biological Foundations of Behavior	9

B.S. Computational Biology

The Bachelor of Science in Computational Biology is listed in the Intercollege (p. 77) section of this catalog. It is a joint degree program offered between the Mellon College of Science and the School of Computer Science. Current MCS students interested in pursuing this degree should contact Dr. Becki Campanaro (DH 1321). More information can also be found on the CMU Computational Biology website (<http://lane.compbio.cmu.edu>).

B.S. Neuroscience

The Bachelor of Science in Neuroscience is listed in the Intercollege (p. 77) section of this catalog. It is a joint degree program offered between the Mellon College of Science and the Dietrich College of Humanities and Social Sciences. Current MCS students interested in pursuing this degree should contact Dr. Maggie Braun (DH 1322). More information can also be found on the CMU Neuroscience website (<http://www.cmu.edu/neuro>).

B.S. Biological Sciences and Psychology

This major is intended to reflect the interdisciplinary nature of current research in the fields of biology and psychology, as well as the national trend in some professions to seek individuals broadly trained in both the social and natural sciences.

Note: Students entering from the College of Humanities and Social Sciences will earn a Bachelor of Science in Psychology and Biological Sciences.

Students in the Mellon College of Science will earn a Bachelor of Science in Biological Sciences and Psychology. Students in the joint Science and Humanities Scholars (SHS) program can complete the SHS educational core and choose either departmental order for their diploma.

Depending on a student's home college (H&SS or MCS), General Education (GenEd) requirements will be different. GenEd requirements for H&SS (p. 202) and MCS (p. 307) are found on their respective Catalog pages.

Degree Requirements:

Biological Sciences	Units
03-121 Modern Biology	9
03-231 Biochemistry I	9
03-240 Cell Biology	9
03-330 Genetics	9
03-343 Experimental Techniques in Molecular Biology	12
03-411 Topics in Research	1
03-412 Topics in Research	1
03-xxx General Biology Elective	9
03-3xx Advanced Biology Elective	9
03-3xx Advanced Biology Elective	9
Total Biology units	77

Mathematics, Statistics, Physics and Computer Science	Units
21-120 Differential and Integral Calculus	10
21-122 Integration and Approximation	10
or 21-124 Calculus II for Biologists and Chemists	
36-247 Statistics for Lab Sciences	9
or 36-201 Statistical Reasoning and Practice	
36-309 Experimental Design for Behavioral and Social Sciences	9
33-111 Physics I for Science Students ^{MCS students must complete Physics II also (either 33-112 or 33-122)}	12
15-110 Principles of Computing *	10
99-10x Computing at Carnegie Mellon	3
Total Science units	63

Chemistry	Units
09-105 Introduction to Modern Chemistry I	10
09-106 Modern Chemistry II	10
09-217 Organic Chemistry I	9
or 09-219 Modern Organic Chemistry	
09-218 Organic Chemistry II	9
or 09-220 Modern Organic Chemistry II	
09-221 Laboratory I: Introduction to Chemical Analysis	12
09-222 Laboratory II: Organic Synthesis and Analysis	12
Total Chemistry units	62

Psychology Courses	Units
85-102 Introduction to Psychology	9
85-219 Biological Foundations of Behavior	9
85-2xx Survey Psychology Courses **	18
85-310 Research Methods in Cognitive Psychology	9
or 85-340 Research Methods in Social Psychology	
or 85-320 Research Methods in Developmental Psychology	
or 85-314 Cognitive Neuroscience Research Methods	
or 85-330 Analytic Research Methods	
85-3xx Advanced Psychology Electives	18
Total Psychology units	63

** Excluding 85-261 Abnormal Psychology

Additional Advanced Elective

9 units(Choose one of the following courses)

85-3xx Advanced Psychology Elective	9
or	
03-3xx Advanced Biology Elective	9

Additional Laboratory or Research Methods

9-12 units(Choose one of the following courses)

03-344 Experimental Biochemistry	12
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03-345 Experimental Cell and Developmental Biology	12
85-310 Research Methods in Cognitive Psychology	9
85-314 Cognitive Neuroscience Research Methods	9
85-320 Research Methods in Developmental Psychology	9
85-340 Research Methods in Social Psychology	9

Elective Units	Units
Free Electives	33-36
MCS Nontechnical Breadth or DC General Education requirements	36-48

Total Elective units 0

360

Minimum number of units required for degree:

B.A. Biological Sciences

The Department of Biological Sciences offers a Bachelor of Arts (B.A.) degree that is intended for students who wish to combine their interest in science with their interest(s) in other discipline(s) across campus. The requirements for the B.A. degree are distributed as follows:

Degree Requirements:

Biological Sciences	Units
03-121 Modern Biology	9
03-231 Biochemistry I	9
03-240 Cell Biology	9
03-201/202 Undergraduate Colloquium for Sophomores	2
03-330 Genetics	9
03-343 Experimental Techniques in Molecular Biology	12
or 03-124 Modern Biology Laboratory	
03-411 Topics in Research	1
03-412 Topics in Research	1
03-xxx General Biology Electives ⁵	18
03-3xx Advanced Biology Electives ⁶	18
Total Biology units	88

^{5,6} Please see description and requirements for electives under the B.S. in Biological Sciences section of this Catalog.

Chemistry	Units
09-105 Introduction to Modern Chemistry I	10
09-106 Modern Chemistry II	10
09-217 Organic Chemistry I	9
or 09-219 Modern Organic Chemistry	
09-218 Organic Chemistry II	9
or 09-220 Modern Organic Chemistry II	
09-221 Laboratory I: Introduction to Chemical Analysis	12
Total Chemistry units	50

Mathematics, Physics, and Computer Science	Units
21-120 Differential and Integral Calculus	10
21-122 Integration and Approximation	10
or 21-124 Calculus II for Biologists and Chemists	
33-111 Physics I for Science Students	12
33-122 Physics II for Biological Sciences and Chemistry Students ⁷	9
02-201 Programming for Scientists ⁸	12
99-10x Computing at Carnegie Mellon	3
Total Science units	56

⁷ 33-112 Physics II for Science Students can substitute for 33-122 Physics II for Biological Sciences and Chemistry Students towards completion of the Physics II requirement.

⁸ 15-112 Fundamentals of Programming and Computer Science or 15-110 Principles of Computing can substitute for 02-201 towards completion of the Programming course requirement.

Elective courses	Units
MCS Nontechnical Breadth Requirements	72
Free Electives	99-102
Total Elective units	72

360 Minimum number of units required for degree:

Masters Degree in Computational Biology

Students who are interested in more advanced training in this emerging field may want to consider the Master of Science Program in Computational Biology. For more information about this program, contact the Biological Sciences Graduate Programs Office (bio-gradoffice@andrew.cmu.edu).

Honors Program in Research Biology

The departmental Honors Program offers an opportunity to become extensively involved in research. The program requires students to conduct an independent project and to prepare a formal thesis that is written and defended in the senior year. This program does not preclude a student from completing any of the options within the department nor is it the only way in which students can participate in undergraduate research, although it is excellent preparation for graduate studies.

Minor in Biological Sciences

All university students are eligible to pursue a minor in biological sciences in conjunction with a major in any other department in the university. A minimum of six biological sciences courses (and two chemistry prerequisites) must be completed to fulfill the minor in biological sciences. The curriculum includes four required courses and two elective courses as specified below. Units awarded for undergraduate research are not applicable to elective courses. Courses taken in other departments or colleges will be considered on an individual basis.

Courses for the Minor in Biological Sciences

Prerequisites:		Units
09-105	Introduction to Modern Chemistry I	10
09-217	Organic Chemistry I	9
Required courses:		Units
03-121	Modern Biology	9
03-231/232	Biochemistry I	9
03-240	Cell Biology	9
03-330	Genetics	9
03-xxx	General Biology Elective	9
03-3xx	Advanced Biology Elective	9

73 Minimum number of units required for the Minor in Biological Sciences:

Minor in Neuroscience

The curriculum within the Neuroscience minor will allow students from various disciplines to gain fundamental knowledge of neuroscience concepts. The interdisciplinary nature of the coursework echoes the nature of the field itself; students will select courses from the natural, social, and computer sciences. Neuroscientists not only require foundational knowledge of molecular, cellular, and systems neuroscience, but they should also understand the behavioral significance and appreciate how computational work and imaging techniques can aid in clarifying normal and abnormal functioning of these fundamental processes.

Students pursuing the minor in Neuroscience will:

- Acquire foundational knowledge of the basic biological foundations of the nervous system, from the cellular through systems levels.
- Understand the effects of basic neurological function on behavior, including cognition.
- Gain an appreciation of the interdisciplinary nature of the field of neuroscience.

NOTE: Because the curriculum within this minor may overlap with some degree requirements, no more than 2 courses fulfilling Neuroscience Minor requirements may count towards the requirements of a student's major or other minor.

Courses required for the Neuroscience minor

Required courses (4):

03-121	Modern Biology	9
03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
85-219	Biological Foundations of Behavior	9
or 03-161	Molecules to Mind	

Distribution Requirements: Three courses, including at least 1 from each of the following categories:

Approaches to Neuroscience Category		Units
15-386	Neural Computation	9
15-883	Computational Models of Neural Systems	12
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing	9
85-429	Cognitive Brain Imaging	9
Cognitive Neuroscience Category		Units
03-260	Neurobiology of Disease	9
03-364	Developmental Neuroscience	9
15-486	Artificial Neural Networks	12
85-211	Cognitive Psychology*	9
85-356	Music and Mind: The Cognitive Neuroscience of Sound	9
85-370	Perception	9
85-390	Human Memory	9
85-406	Autism: Psychological and Neuroscience Perspectives	9

*NOTE: 85-213 may be used instead of 85-211 when offered

Minimum number of units required for the Neuroscience Minor: 63

Transfer credit for Modern Biology

Students wishing to transfer credit for 03-121 Modern Biology from another institution must meet the following requirements:

1. The course in question should have at least an 80% match in topics with 03-121. Topics in 03-121 cover the genetic, molecular, cellular, developmental, and evolutionary mechanisms that underlie biological processes and include: Cell theory; Cell chemistry; Cell structure; Function and structure of proteins, DNA, RNA, lipids and carbohydrates; Cell respiration and fermentation; The cell cycle; Cell-cell interactions and communication; Transcription; Translation; RNA processing in Eukaryotes; DNA replication; DNA mutation and repair; Meiosis; Mitosis; and Regulation of Gene Expression.
This information is sometimes available in the course description, but more detail is often found in a course syllabus.
2. The textbook used in the transfer course should be at a comparable level to S. Freeman (2010) "Biological Science, Vol. 1 (The Cell, Genetics, and Development)," Fourth Edition, Pearson Benjamin Cummings, ISBN 0-321-61347-3.
3. Introductory level courses that focus on other biology areas (i.e. anatomy, physiology, ecology, evolution, and/or development) will not be accepted for 03-121 credit. These courses may receive credit for a general biology elective.
4. Students should contact their departmental academic advisor for the transfer credit approval process in their college.

Faculty

ALISON L. BARTH, Professor - Ph.D., University of California, Berkeley; Carnegie Mellon, 2002-.

MOHAMED BOUAQUINA, Assistant Teaching Professor - Ph.D., Carnegie Mellon, 2013-.

DANIEL BRASIER, Assistant Teaching Professor - Ph.D., University of California, San Diego; Carnegie Mellon, 2012-.

MAGGIE BRAUN, Associate Teaching Professor and Director of MCS Core Education - Ph.D., University of Pittsburgh; Carnegie Mellon, 2008-.

Units

MARCEL BRUCHEZ, Associate Professor in Biological Sciences and Chemistry, Associate Director of MBIC – Ph.D., University of California, Berkeley; Carnegie Mellon, 2006–.

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JONATHAN W. JARVIK, Associate Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1978–.

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ADAM D. LINSTEDT, Professor – Ph.D., University of California, San Francisco; Carnegie Mellon, 1995–.

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JAMES F. WILLIAMS, Professor Emeritus – Ph.D., University of Toronto; Carnegie Mellon, 1976–.

C. ROY WORTHINGTON, Professor Emeritus – Ph.D., Adelaide University; Carnegie Mellon, 1969–.

Department of Chemistry

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Carnegie Mellon provides a family-like but very vibrant and interdisciplinary environment for science students. One of our major strengths is that most of our undergraduate students in chemistry and related fields get involved in research in faculty labs early on and get hands-on experience in cutting-edge research, some even as freshmen. Our curriculum is both fluid and innovative to give students a broad background and in-depth knowledge in chemistry and interdisciplinary areas. — Dr. Hyung J. Kim

Chemistry is an area of science involved with the study of the properties and reactions of substances ranging from living cells to subatomic particles. It is at the center of many sciences and technical fields, providing the fundamental knowledge and tools needed to address many of society's needs and to explore the unknown. Fields as diverse as genetic engineering, materials science and nanotechnology look to chemistry when they look to the future, for that is where the ultimate in understanding — the molecular level — resides.

The chemistry profession is extraordinarily diverse, with career opportunities available in the chemical, petroleum, renewable energy, nuclear power, novel polymeric materials, metals, and pharmaceutical industries, among many others. Chemistry plays an increasingly important role in the rapidly expanding biomedical and biotechnology industries. In addition to careers in industry and academia, many chemists find challenging careers in the public sector in the laboratories of the National Institutes of Health, the Department of Agriculture, the Environmental Protection Agency, the National Institute of Standards and Technology, and the Department of Energy as well as in consulting. Chemistry alums also find employment in technical fields unrelated to science but where their problem solving and communication skills are highly valued.

Chemistry is a particularly suitable major for pre-medical and other pre-health profession students. Medical schools look favorably on the rigorous reasoning skills chemists develop, as evidenced by an excellent record for student admission to advanced education in these areas. An increasing number of our graduates are seeking careers in dentistry, pharmacy or pharmacology. The Health Professions Program advises all Carnegie Mellon students considering careers in health fields. (See Health Professions Program description in this catalog for more information.) Chemistry is particularly attractive to pre-law majors anticipating a career in a legal department in the chemical industry, in patent, intellectual property or environmental law. Students interested in industrial careers often combine their chemistry program with undergraduate courses in business administration or eventually go on to study for an M.B.A.

The Department offers three Bachelor's degrees: the B.S. in Chemistry, The B.S. in Chemistry/Biological Chemistry Track and the B.A. in Chemistry. One third of the courses for the B.A. degree are free electives that may be taken in any of the departments of the University and therefore offers a high degree of flexibility. For the B.S. degrees, electives often are technical courses in chemistry or related fields of science, technology and engineering, such as biology, physics, mathematics, chemical, biomedical or materials science engineering or computer science, although they can be in other non-technical areas as well. It is possible to have all of the technical requirements completed after the junior year in the B.S. and B.A. degree programs, allowing students the flexibility to combine electives in the senior year into a focused program of specialization or to allow for additional breadth in their undergraduate experience. Students interested in graduate studies in chemistry may enroll in graduate courses. Those desiring immediate job placement may be interested in one or more of the formal options that supplement the chemistry B.S. degree. These are described in detail later. Carnegie Mellon has one of the strongest polymer science programs in the world and the undergraduate polymer science, materials chemistry or colloids, polymers and sciences options offer training that is particularly valuable for an industrial career. The Computational Chemistry option provides students with expertise in scientific computing that is highly sought after by employers in the pharmaceutical industry.

The overlap between the fields of chemistry and biological sciences continues to grow, with increased emphasis on synthetic chemicals that are used as probes or reporters of biological function and diagnostic and/or therapeutic agents. In addition, the application of sophisticated spectroscopic, structural and scanning probe/force methods on scales as low as single molecules is driving innovation and education at the chemistry/biology interface. Based on these trends the department offers the B.S. in Chemistry/Biological Chemistry Track to better prepare students for

advanced studies and a job market that values knowledge and skills from both disciplines. A combination of advanced research-focused lecture course offerings and a new laboratory course allows students to build the strong foundation typical of a successful chemistry major, while expanding out into applications of chemistry in the biological sciences. Students who complete the track will have been exposed to the latest research accomplishments and unanswered questions in biological chemistry while also gaining experience in experimental methods unique to research at this interface.

An honors program is offered for highly motivated undergraduates. It is designed primarily for students who wish to undertake a strong research-intensive program of study in contemporary chemistry. The program B.S. in Chemistry with Departmental Honors requires the completion of at least one graduate level course in chemistry, a research project, and the writing and defense of a bachelor's level honors thesis. An advanced track leading to the B.S. in Chemistry with Departmental Honors together with a Masters Degree in Chemistry involves completion of five graduate level courses and a more extensive thesis research project. This degree path is especially attractive to students who plan to pursue an industrial career. With enough advanced placement credit or by carrying heavier than usual course loads, students can complete the Honors/M.S. degree program in 8 semesters.

The majority of openings in the chemical industry presently are at the Bachelors and Masters degree levels.

Additional majors (double majors) are available with nearly all other departments provided the student can fit the required courses into the schedule. Generally, all the requirements for both departments must be met for an additional major (except for some courses with similar content). Programs are also available that lead to the degree B.S. in Chemistry with a minor in another discipline such as biological sciences, physics, mathematics, computer science, engineering studies, business administration and certain departments in the Dietrich College of Humanities and Social Sciences. Requirements for most minor programs are described by individual departments in this catalog. However, it is recommended that students who are interested in pursuing a minor as part of their degree consult with the department involved for the current requirements and further guidance about scheduling. Dual degree programs are available in which students receive two separate undergraduate degrees from two different departments in the University. These require students to complete at least 90 units of work per additional degree in addition to the units required for the first degree and the core curriculum from both colleges if the programs are in different units. Several five-year programs have been developed to allow a Carnegie Mellon undergraduate student to earn both a B.S. in Chemistry and a Master of Science degree in fields such as Health Care Policy and Management, Materials Science Engineering or Biomedical Engineering.

Study abroad programs are available for chemistry majors and programs of one to two semesters can generally be accommodated without delaying time to graduation beyond 8 semesters. One example of a formal exchange program is spending two semesters at École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. Study abroad is encouraged by the chemistry department and also can be arranged on an individual basis at universities throughout the world including Europe, Asia, Africa, New Zealand, and Australia during the academic year, the summer and winter or spring breaks. Students interested in study abroad should consult with their academic advisor and the MCS Study Abroad Advisor.

One of the most attractive features of the Department of Chemistry is the opportunity for students to interact with prominent research scientists in entry-level as well as advanced courses and in research. Since the spring of 2003, undergraduate laboratory instruction takes place in a state-of-the-art facility located in Doherty Hall. Participation in undergraduate research is encouraged and qualified students may begin projects as early as their second year. Chemistry majors interested in beginning research should consult with the Director of Undergraduate Studies to begin the process of identifying a research mentor. Approximately 90 to 98% of the graduating chemistry majors during the past ten years have taken part in research either for pay or for credit as part of their undergraduate training. Chemistry majors have been very successful in obtaining Small Undergraduate Research Grants (SURG) and Summer Undergraduate Research Fellowships (SURF) from the University to help support their research projects. Undergraduate and research laboratories are equipped with the latest scientific instrumentation. The use of computational tools is emphasized throughout the curriculum.

Program Outcomes

The faculty members of the Department of Chemistry have approved the following as a statement of our learning outcomes for recipients of an undergraduate degree in chemistry.

Upon graduation recipients of the BS or BA degree in Chemistry will:

Foundational knowledge/theory

- Have a firm foundation in the quantitative and computational thinking that underlies chemistry, including use of modern computational tools.
- Have a firm foundation in the theories and models that form the basis for reasoning about molecular systems.
- Understand how the different subdisciplines of chemistry relate to and complement one another.
- Be able to apply chemical reasoning across disciplines, such as biology, environmental science, materials science, nanotechnology, and engineering.

Practical/Experimental

- Understand that chemistry is fundamentally an experimental science, and be able to identify or create an appropriate model, formulate a hypothesis, choose an appropriate set of tools and techniques, and design an experiment that tests the hypothesis and analyze the results from that experiment drawing sound scientific conclusions from the results obtained.
- Be proficient in the use of both classical and modern tools for analysis of chemical systems.
- Be able to design and carry out synthesis of both organic and inorganic systems.
- Be able to use experience and knowledge gained through theoretical and practical design projects to conduct further research.
- Know and follow the proper procedures and regulations for safe handling and use of chemicals and chemical equipment.

Communication

- Be able to convey information, both orally and in writing, to a range of audience levels and for a variety of purposes.
- Understand how scientific information is shared between peers in modern science, including responsible conduct for acknowledging prior and current contributions.
- Be able to locate, identify, understand and critically evaluate the chemical literature.
- Develop the interpersonal skills to function cooperatively in a team setting.

Society and ethics

- Understand the opportunities and consequences of chemistry for the environment and society for both the short term and for long-term sustainability.
- Understand and apply ethics and values to all professional activities.

Professional development

- Develop an understanding of career opportunities both within and outside of chemistry, including through contacts with faculty, the career and professional development center and alumni.
- Be prepared to pursue a life and career that builds on their experiences at Carnegie Mellon to achieve their personal goals and to contribute positively to society.

B.S. in Chemistry

The majority of undergraduate degrees awarded by the Department of Chemistry are Bachelor of Science degrees. This degree program provides the most appropriate preparation for further graduate study and for research and development or analytical positions in industry. The curriculum provides a strong foundation in the fundamental areas of study in chemistry: organic, physical, inorganic and analytical chemistry, along with a rich set of research-focused, instrumentation intensive laboratory experiences aligned with those areas. Students interested in less technical areas of employment or graduate study in areas such as business, policy or law may find the Bachelor of Arts degree a more suitable alternative.

Curriculum - B.S. in Chemistry and Requirements for an Additional Major in Chemistry

This catalog and the sample schedules presented are intended to be used by students in the first year class entering in the fall of 2015. Upperclass students should refer to the appropriate previous version of the catalog published during their first year for the requirements that are specific to them.

The technical breadth requirement of the MCS core curriculum, starting with the entering class of 2015, requires a minimum of four technical courses outside of the student's primary major. Chemistry majors must at minimum take the following non-chemistry technical courses:

Technical Breadth Requirements		Units
33-121	Physics I for Science Students	12
33-122	Physics II for Biological Sciences and Chemistry Students	9
03-121	Modern Biology	9
or 03-231	Biochemistry I	
or 03-232	Biochemistry I	
15-110	Principles of Computing - or other approved programming course	10
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	

Students should complete this technical core as early as possible and preferably by the end of their fifth semester.

The non-technical breadth requirements for MCS students includes 76-101 Interpretation and Argument, four courses with a minimum of 36 units from the arts, humanities or social sciences and a course of at least 9 units from an approved list in the category of Cultural/Global understanding, Three ENGAGE in Wellness courses, one ENGAGE in Service course, one ENGAGE in the Arts course, EUREKA! Discovery and its Impact, the MCS first-year seminar, and the MCS Junior Seminar for a total of 72 units. For more information on allowed courses, refer to the MCS section of this catalog.

Freshman Year

Fall		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
21-120	Differential and Integral Calculus	10
33-111	Physics I for Science Students (to be renumbered as 33-121 starting in the spring of 2016)	12
or 03-121	Modern Biology	
or 15-110	Principles of Computing	
76-101	Interpretation and Argument	9
38-101	EUREKA!: Discovery and Its Impact	6
99-101	Computing @ Carnegie Mellon	3
		50

Students interested in majoring in chemistry who have a strong chemistry background, should enroll in 09-107 rather than 09-105. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II.

02-201 Programming for Scientists is an acceptable alternative to 15-110 for chemistry majors as are any upper level courses in programming.

There are some elective laboratory courses offered for MCS students in the first year. These include 03-115 Phage Genomics Research and 09-122 Molecular Tools for Biological and Chemical Studies. The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take an alternate technical course to Physics I such as 15-110 so that their unit total is lower.

Spring		Units
09-106	Modern Chemistry II	10
Chemistry majors who place out of 09-106 can take 09-348 Inorganic Chemistry		
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
33-121	Physics I for Science Students	12

or 03-121	Modern Biology	
or 15-110	Principles of Computing	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	9.0
		50

Sophomore Year

Fall		Units
09-201	Undergraduate Seminar I	1
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
33-122	Physics II for Biological Sciences and Chemistry Students Course is a prerequisite for 09-331, normally taken in the spring of the junior year	9
xx-xxx	Arts, Humanities and Social Sciences Course 2	9
		41

Spring		Units
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-204	Professional Communication Skills in Chemistry (It is recommended that this course be completed prior to taking the junior level labs, 09-321 or 09-323.)	3
09-220	Modern Organic Chemistry II	10
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-348	Inorganic Chemistry (Students wishing to pursue careers in the health professions may wish to take biochemistry, 03-232, and delay inorganic until the junior or senior year spring semester)	10
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Sciences Course 3	9
		46

Junior Year

Fall		Units
09-301	Undergraduate Seminar III	1
09-231	Mathematical Methods for Chemists	9
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Arts, Humanities and Social Sciences course 4	9
		41

Spring		Units
09-302	Undergraduate Seminar IV	1
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-331	Modern Analytical Instrumentation	9
38-301	MCS Junior Seminar	6
xx-xxx	Cultural/Global Understanding Requirement	9
		46

Senior Year

Fall		Units
09-401	Undergraduate Seminar V	1
09-xxx	Chemistry Elective (see notes on electives)	9
38-110	ENGAGE in Service	1
38-430	ENGAGE in Wellness: Looking Forward	1
xx-xxx	Free Electives	30
		42

Spring		Units
09-402	Undergraduate Seminar VI	3

09-xxx	Chemistry Elective (see notes on electives)	9
38-220	ENGAGE in the Arts	2
xx-xxx	Free Electives	27
		41

Distribution of Units for the B.S. in Chemistry and Requirements for An Additional Major in Chemistry

Minimum Total Chemistry Units 163; See distribution below

Required Chemistry Courses* Units		
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-204	Professional Communication Skills in Chemistry	3
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10
09-231	Mathematical Methods for Chemists	9
09-331	Modern Analytical Instrumentation	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-xxx	Chemistry Seminars	8
09-xxx	Chemistry Electives	18

* These, plus 33-121 Physics I for Science Students and 33-122 Physics II for Biological Sciences and Chemistry Students, are the required courses for students earning an additional major in chemistry.

Students who transfer into the department and have taken 09-217 Organic Chemistry I and/or 09-218 Organic Chemistry II, will be required to complete units of 09-435 Independent Study Chemistry, 1 unit per course, under the supervision of the instructor(s) for 09-219 and/or 09-220 in order to master the course content missed in this course sequence.

Chemistry courses required for the BS degree and the additional major in chemistry that are numbered 09-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested of and approved by the Director of Undergraduate Studies. In general such requests will be approved only under unusual or extenuating circumstances.

Other Requirements	Units
Biology (Modern Biology or Biochemistry)	9
Computer Science	10
Mathematics	20
Physics	21
Interpretation and Argument	9
Arts, Humanities and Social Sciences Courses	36
Cultural/Global Understanding	9
EUREKA! (First-year seminar)	6
MCS Junior Seminar	6
ENGAGE in Service	1
ENGAGE in Wellness Courses (three courses)	3
ENGAGE in the Arts	2
Computing @ Carnegie Mellon	3
Free Electives	62
Minimum number of units required for the degree:	360

The above B.S. curriculum recommends a range of 41-50 units per semester to meet the minimum degree requirement of 360 units. Students are strongly encouraged to take extra elective courses (except in the first year)

in whatever subjects they wish in order to enrich their backgrounds and enhance their educational experience.

Notes on Electives

Chemistry Electives

A minimum of 18 units of chemical electives is required.

Chemistry electives can be satisfied by 09-445 Undergraduate Research, or by most other chemistry courses 09-3xx or higher, undergraduate or graduate level, for which the student has the necessary prerequisites, or by 03-231/03-232 Biochemistry. Biochemistry also fulfills the Life Sciences requirement for the MCS technical breadth requirement. 09-435 Independent Study Chemistry may only be used to fulfill this requirement with permission of the Director of Undergraduate Studies. Certain interdisciplinary courses (e.g. 39-xxx) relating to chemistry can also be used with the approval of the Director of Undergraduate Studies. The scheduling of these electives can vary and students should check with the department offering the course to see which courses are offered in any given year or semester and with the Director of Undergraduate Studies in the Department of Chemistry to ascertain whether the course is an acceptable chemistry elective.

Free Electives

Free electives are defined as including any course offered by Carnegie Mellon except those in science or engineering fields that are primarily intended for non-majors. A maximum of 9 units total of Physical Education, StuCo and/or ROTC courses combined can be counted as free elective units. The Chemistry Department does not require technical electives.

B.S. in Chemistry/Biological Chemistry Track

This degree is ideal for students who wish to better prepare themselves for advanced studies in biological chemistry or biomedical fields and a job market that values knowledge and skills from both disciplines. A combination of advanced research-focused lecture course offerings and a new laboratory course will allow students to build the strong foundation typical of a successful chemistry major, while expanding out into applications of chemistry in the biological sciences.

Curriculum - B.S. in Chemistry/Biological Chemistry Track

This catalog and the sample schedules presented are intended to be used by students in the first year class entering in the fall of 2015. Upperclass students should refer to the appropriate previous version of the catalog published during their first year for the requirements that are specific to them.

The technical breadth requirement of the MCS core curriculum, starting with the entering class of 2015, requires a minimum of four technical courses outside of the student's primary major. Chemistry majors in the Biological Chemistry Track must at minimum take the following non-chemistry technical courses: 33-121 Physics I for Science Students, 33-122 Physics II for Biological Sciences and Chemistry Students, 03-121 Modern Biology, 15-110 Principles of Computing (or other approved programming course), 21-120 Differential and Integral Calculus and 21-122 Integration and Approximation **or** 21-124 Calculus II for Biologists and Chemists. Students should complete this technical core as early as possible and preferably by the end of their fifth semester.

The non-technical breadth requirements for MCS students includes 76-101 Interpretation and Argument, four courses with a minimum of 36 units from the arts, humanities or social sciences and a course of at least 9 units from an approved list in the category of Cultural/Global understanding, Three ENGAGE in Wellness courses, one ENGAGE in Service course, one ENGAGE in the Arts course, EUREKA! Discovery and its Impact, the MCS first-year seminar, and the MCS Junior Seminar for a total of 72 units. For more information on allowed courses, refer to the MCS section of this catalog.

Freshman Year

Fall		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
21-120	Differential and Integral Calculus	10

33-111	Physics I for Science Students (to be renumbered as 33-121 starting in the spring of 2016)	12
or 03-121	Modern Biology	
76-101	Interpretation and Argument	9
38-101	EUREKA!: Discovery and Its Impact	6
99-101	Computing @ Carnegie Mellon	3
		50

Students interested in majoring in chemistry who have a strong chemistry background, should enroll in 09-107 rather than 09-105. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II.

02-201 Programming for Scientists is an acceptable alternative to 15-110 for chemistry majors as are any upper level courses in programming.

There are some elective laboratory courses offered for MCS students in the first year. These include 03-115 Phage Genomics Research and 09-122 Molecular Tools for Biological and Chemical Studies. The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take 03-121 Modern Biology so that their unit total is lower and they get a start on their required biology courses.

Spring		Units
09-106	Modern Chemistry II Chemistry majors who place out of 09-106 can take 09-348 Inorganic Chemistry	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
03-121	Modern Biology	9
or 33-121	Physics I for Science Students	
or 15-110	Principles of Computing	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	5
		43

Sophomore Year

Fall		Units
09-201	Undergraduate Seminar I	1
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
03-231	Biochemistry I	9
33-122	Physics II for Biological Sciences and Chemistry Students Course is a prerequisite for 09-331, normally taken in the spring of the junior year	9
xx-xxx	Arts, Humanities and Social Sciences Course 2	9
		50

Spring		Units
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-204	Professional Communication Skills in Chemistry (It is recommended that this course be completed prior to taking the junior level lab, 09-323.)	3
09-220	Modern Organic Chemistry II	10
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-348	Inorganic Chemistry (alternatively a biological chemistry elective could be taken and 09-348 moved to the spring of the junior or senior years)	10
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Sciences Course 3	9
		46

Junior Year

Fall		Units
09-301	Undergraduate Seminar III	1
09-231	Mathematical Methods for Chemists	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-323	Bioorganic Chemistry Laboratory	12
38-330	ENGAGE in Wellness: Looking Outward	1

xx-xxx	Arts, Humanities and Social Sciences Course 4	9
		41
Spring		Units
09-302	Undergraduate Seminar IV	1
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry (or a Biological Chemistry Elective)	10
38-301	MCS Junior Seminar	6
xx-xxx	Cultural/Global Understanding Requirement	9
		47

Senior Year

Fall		Units
09-401	Undergraduate Seminar V	1
09-xxx	Biological Chemistry Elective 1 (see notes on electives)	9
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
or 09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
38-110	ENGAGE in Service	1
38-430	ENGAGE in Wellness: Looking Forward	1
xx-xxx	Free Electives	21
		42

Spring		Units
09-402	Undergraduate Seminar VI	3
xx-xxx	Biological Chemistry Elective 2	9
xx-xxx	Biological Chemistry Elective 3	9
38-220	ENGAGE in the Arts	2
xx-xxx	Free Electives	18
		41

Distribution of Units for the B.S. in Chemistry/Biological Chemistry Track

Minimum Total Chemistry Units 190; See distribution below

Required Chemistry Courses* Units

09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-204	Professional Communication Skills in Chemistry	3
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10
03-231	Biochemistry I	9
or 03-232	Biochemistry I	
09-231	Mathematical Methods for Chemists	9
09-331	Modern Analytical Instrumentation	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
or 09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-323	Bioorganic Chemistry Laboratory	12
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-xxx	Chemistry Seminars	8
09-xxx	Biological Chemistry Electives	27

Students who transfer into the department and have taken 09-217 Organic Chemistry I and/or 09-218 Organic Chemistry II, will be required to complete units of 09-435 Independent Study Chemistry, 1 unit per course, under the supervision of the instructor(s) for 09-219 and/or 09-220 in order to master the course content missed in this course sequence.

Chemistry courses required for the BS degrees that are numbered 09-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested of and approved by the Director of Undergraduate Studies. In general such requests will be approved only under unusual or extenuating circumstances.

Other Requirements	Units
Modern Biology	9
Computer Science	10
Mathematics	20
Physics	21
Interpretation and Argument	9
Arts, Humanities and Social Sciences courses	36
Cultural/Global Understanding	9
EUREKA! (First Year Seminar)	6
MCS Junior Seminar	6
ENGAGE in Wellness (3 courses)	3
ENGAGE in Service	1
ENGAGE in the Arts	2
Computing @ Carnegie Mellon	3
Free Electives	35
Minimum number of units required for the degree:	360

The above B.S. curriculum recommends a range of 41-50 units/semester to meet the minimum degree requirement. Students are strongly encouraged to take extra elective courses (except in the first year) in whatever subjects they wish in order to enrich their backgrounds and enhance their educational experience.

NOTES ON ELECTIVES

Biological Chemistry Electives

A minimum of three biological chemistry electives for a total of 27 units or more is required.

A list of currently approved electives is provided below. One semester of 09-445 for 9 units may be used for 1 biological chemistry elective with the approval of the Undergraduate Advising and Curriculum Committee. It must be part of a longer term experience ensuring depth of knowledge in the area.

09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates (One of these two courses is required for the degree. The other can be used as a Biological Chemistry elective.)	9
or 09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
09-535	Applied topics in Macromolecular and Biophysical Techniques	9
09-705	Chemosensors and Biosensors	12
09-716	Bioactive Natural Products	6
09-803	Chemistry of Gene Expression	12
03-240	Cell Biology	9
03-330	Genetics	9
03-344	Experimental Biochemistry	12
03-362	Cellular Neuroscience	9
03-439	Introduction to Biophysics	9
03-534	Biological Imaging and Fluorescence Spectroscopy	9
03-740	Advanced Biochemistry	12
03-871	Structural Biophysics	12
33-441	Introduction to BioPhysics	10

Free Electives

Free electives are defined as including any course offered by Carnegie Mellon except those in science or engineering fields that are primarily intended for non-majors. A maximum of 9 units total of Physical Education,

StuCo and/or ROTC courses combined can be counted as free elective units. The Chemistry Department does not require technical electives.

Options for the B.S. in Chemistry

The curriculum for the degree Bachelor of Science in Chemistry permits students to take a number of elective courses in chemistry and other fields, particularly in the junior and senior years. Students may wish to complete a group of elective courses from several specialty areas, called "options," to complement their technical education. Each option will complement the Bachelor's degree in Chemistry and will provide students with expertise in a specific area not covered by the normal undergraduate curriculum. Options are noted on the student's transcript but not on the diploma.

For each of the following options, the student should refer to the previous description of the curriculum for the B.S. in chemistry. Required courses are unchanged, and the courses that should be taken as electives for each option are listed below. Chemistry courses within an option also count towards fulfillment of the chemistry elective requirement for the B.S. degree.

A student who completes the recommended courses for any of these options will receive a certificate from the Department of Chemistry at Commencement as formal evidence of the accomplishment and a notation of this will be made on the student's transcript.

BIOCHEMISTRY OPTION		Units
03-231/232	Biochemistry I	9
03-330	Genetics	9
03-344	Experimental Biochemistry	12
xx-xxx	Elective in Biochemistry	

Elective course may be chosen from the following list

03-439	Introduction to Biophysics	9
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
03-740	Advanced Biochemistry	12

POLYMER SCIENCE OPTION		Units
06-466	Experimental Polymer Science	9
09-502	Organic Chemistry of Polymers	9
09-509	Physical Chemistry of Macromolecules	9
09-xxx	Elective in Polymer Science	9

Elective course may be chosen from the following list

09-531	Polymer Science	9
09-445	Undergraduate Research (in a polymer area as approved by the Director of Undergraduate Studies and generally part of a longer term project)	9
27-324	Introduction to Polymer Science and Engineering	9

Other upper level courses in chemistry, biomedical engineering, materials science engineering or the colloids, polymers and surfaces program may be used with permission of the Director of Undergraduate Studies

COLLOIDS, POLYMERS and SURFACES OPTION (offered jointly with the Department of Chemical Engineering)		Units
06-426	Experimental Colloid Surface Science	9
06-466	Experimental Polymer Science	9
09-509	Physical Chemistry of Macromolecules	9
06-607	Physical Chemistry of Colloids and Surfaces	9

MATERIALS CHEMISTRY OPTION		Units
27-100	Engineering the Materials of the Future	12
27-201	Structure of Materials	9

Two Elective Courses of at least 9 units each from the list below

27-202	Defects in Materials	9
09-445	Undergraduate Research (in a materials area as approved by the Director of Undergraduate Studies and generally part of a longer term project)	9
09-502	Organic Chemistry of Polymers	9
09-509	Physical Chemistry of Macromolecules	9
09-531	Polymer Science	9
27-xxx	MSE course approved by Director of Undergraduate Studies	

ENVIRONMENTAL CHEMISTRY OPTION		Units
09-510	Chemistry and Sustainability	9
09-524	Environmental Chemistry	9
Two elective courses of at least 9 units each from the list below		
19-424	Energy and the Environment	9
19-426	Environmental Decision Making	9
19-440	Combustion and Air Pollution Control	9
12-100	Introduction to Civil and Environmental Engineering	12
09-520	Global Atmospheric Chemistry: Fundamentals and Data Analysis Methods	9
06-630	Atmospheric Chemistry, Air Pollution and Global Change	12
19-650	Climate and Energy: Science, Economics and Public Policy	9
12-651	Air Quality Engineering	9
12-657	Water Resource Systems Engineering	9
12-702	Fundamentals of Water Quality Engineering	12

MANAGEMENT OPTION		Units
73-100	Principles of Economics	9
70-101	Introduction to Business Management	9
70-122	Introduction to Accounting	9
70-364	Business Law	9

COMPUTATIONAL CHEMISTRY OPTION		Units
15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10
or 15-150	Principles of Functional Programming	
09-560	Computational Chemistry	12
21-127	Concepts of Mathematics	10
xx-xxx	One Upper Level Computational Elective Course from the list below	
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-213	Introduction to Computer Systems	12
15-214	Principles of Software Construction: Objects, Design, and Concurrency	12
33-241	Introduction to Computational Physics	9
03-250	Introduction to Computational Biology	12
09-701	Quantum Chemistry I	12
09-702	Statistical Mechanics and Dynamics	12

B.S. in Chemistry with Departmental Honors

Outstanding students with an interest in research are encouraged to consider the Honors program by the beginning of the junior year. The program combines a slightly modified B.S. curriculum with close faculty-student contact in an individual research project, concluding with the student's presentation and defense of a bachelor's honors thesis to a Thesis Committee.

The B.S. in Chemistry with Departmental Honors curriculum follows the general sequence of courses that is listed for the B.S. degree. Students are strongly urged to complete all seven of the Science Core Courses as early as possible. The honors program specifies that one of the two chemistry electives be a 12-unit graduate course, numbered 09-7xx or higher, and that of the remaining electives required, at least two be undergraduate research (18 units) and one be 09-455 Honors Thesis (taken for 6 units). Students will be encouraged to do more than the minimum amount of research, so stipends from the research advisor or other sources are sometimes available for summer B.S. honors research.

At any time before the spring term of the senior year, candidates for the B.S. in chemistry may apply to be admitted for candidacy to the Honors B.S. program. Applications are available through the Director of Undergraduate Studies. To be accepted, students will be expected to have shown excellent performance in class work – normally at least a 3.2 average QPA. Upon acceptance into the program, a Thesis Committee must be identified, which will monitor the progress of the student. The committee shall consist of at least one member of the Honors Committee to be appointed by the chair, the student's research advisor and a third faculty member agreed upon by the student and advisor. This third member can be from another department or institution and can be tenure track, teaching track

or research track faculty. It is the student's responsibility to contact the proposed third member of their committee and confirm their participation.

A written thesis suitable for an Honors B.S. degree is required and should be a clear exposition in proper scientific format of a research project done for at least 18 units of credit in 09-445 Undergraduate Research. The thesis should describe a substantive new contribution to a particular field of research. This could include, but is not limited to, the discovery of a new phenomenon, studies that enhance our understanding of a previously reported phenomenon, or the development of a new method or technique. The student's Thesis Committee will evaluate the thesis and will require that each student participate in a public oral presentation or defense of the thesis before it approves the Honors degree. The written thesis must be supplied to the members of the student's Thesis Committee no later than 1 week prior to the scheduled public defense. The defense is usually scheduled to take place during April or early May of the senior year and the Director of Undergraduate Studies will coordinate the selection of a suitable date. Students completing the B.S. with Departmental Honors in Chemistry will receive MCS College Honors as well.

The designations of MCS College Honors and Departmental Honors are noted on the transcript but not on the diploma. Only University Honors are noted on the diploma.

Honors B.S./M.S. Program in Chemistry

Outstanding students seeking an advanced degree are encouraged to apply for admission to the B.S./M.S. Honors program as early as they can but only after having made some progress on a research project that could eventually be suitable for production of a Master's level thesis. Please note that this degree is available only with the B.S. in chemistry and cannot be obtained by students pursuing a B.A. degree in chemistry. Most commonly, applications are submitted during the second half of the sophomore year or early in the junior year. Applications are available through the Director of Undergraduate Studies. Participants will have the opportunity to earn in four years not only the degree B.S. in Chemistry with Departmental Honors, but also the degree Master of Science in Chemistry. This program is highly research intensive and is not appropriate for all students. Requirements include completing five graduate level courses as electives. (See notes on Honors B.S./M.S. electives.)

The schedule of courses for the B.S./M.S. program generally moves as many courses as possible forward in the curriculum, though this is not a requirement. When possible, all Science Core Courses should be completed in the freshman year. This gives the student the following advantages: 1) greater perspective in selection of a research advisor, 2) greater maturity in performing independent research, and 3) the possibility of initiating the graduate course sequence in the junior year. Students can achieve this accelerated schedule through advanced placement or summer school though neither is a requirement.

A completed application, available from Karen Stump, ks01@andrew.cmu.edu, and written note of support from the thesis advisor must be submitted to the Director of Undergraduate Studies who will then arrange for an application meeting with the student, research advisor and Honors Committee. At this meeting the student is expected to give an oral presentation with visual aids that presents relevant background, a summary of work completed to date and a detailed plan for their thesis project.

Upon acceptance into the program, a Thesis Committee must be identified, which will monitor the progress of the student. The committee shall consist of at least one member of the Honors Committee appointed by the committee chair, the student's research advisor and a third faculty member agreed upon by the student and advisor. This third member can be from another department or institution and can be tenure track, teaching track or research track faculty. It is the student's responsibility to contact the third member of their committee and confirm their participation.

The student is expected to keep the research advisor selected by May of the sophomore year for the duration of the thesis project. Summer thesis research for 10 weeks after the sophomore and junior years is strongly suggested to assist the student in completing research of sufficient quantity and quality to complete their thesis. Students normally will be given stipends for their summer work either by their research advisor or by competing for a summer fellowship. A minimum of 3 semesters of undergraduate research is required (normally 10 units/semester), though this is rarely sufficient as the sole research experience, as is participation in group seminars during the junior and senior years. Students must present their research at least once at the Sigma Xi competition at Meeting of the Minds, the annual Carnegie Mellon undergraduate research symposium, typically at the end of the junior year. In addition students must meet with their Thesis Committee each fall to update the committee on their progress and in the fall of the senior year must prepare a written summary of their research progress to date (5 pages) and their plans for the academic year

(1 page). This report must state clearly what stage the work is in; it must be clear what work is complete and ready for publication.

At the start of the spring semester of the senior year (or their final semester if different), the student must submit a draft of the introduction for their thesis and a detailed outline of their methods, results and discussion sections to the Director of Undergraduate Studies who also chairs the Honors Committee. This will be distributed by the department and reviewed by the student's Thesis Committee.

Each student is required to submit a formal Masters Degree dissertation to the Chemistry Department in April of the senior year or at least one week prior to the date set for the thesis defense. The Thesis Committee will evaluate the written thesis and student is required to present their final oral defense of the project before the Thesis Committee. The defense is usually scheduled to take place during April or early May of the senior year and the Director of Undergraduate Studies will coordinate the selection of a suitable date. The public defense is followed by a private question and answer session with the Thesis Committee.

The dissertation, written in proper scientific format, should describe the research project in considerable detail and must withstand the scrutiny of the Thesis Committee with respect to completeness. It need not be as extensive nor contain the element of student originality characteristic of a Ph.D. thesis; however it must contain results and conclusions that are of a high enough quality to be accepted as a publication in a respected research journal. The student should refer to the ACS Style Guide for recommendations on appropriate presentation and formatting of written text, tables, graphs, and figures. As for all M.S. degree candidates in the Department, the dissertation must be approved by the faculty member in charge of the work.

Research productivity is the most important criterion for success at the evaluation points, but QPA is a strong secondary criterion. While we expect that most students will maintain a QPA of 3.5, a minimum of 3.2 must be maintained to remain in the program and will be acceptable only with a strong record of research. Candidates must also maintain a QPA of at least 3.0 in the five graduate level courses required for the degree.

Students who complete this program will receive the designations of Departmental Honors and MCS College Honors. These are designated on the transcript, not on the diploma. Only University Honors are denoted on the diploma.

Students completing the requirements for this degree receive two diplomas, one for the B.S. degree and another for the M.S. degree. Since this is a combined degree program both degrees are awarded at the same time; the awarding of the two degrees cannot be separated in time.

Notes on Honors B.S./M.S. Electives

The B.S./M.S. Honors degree requires the completion of five graduate level courses. These normally are 12-unit courses. However, in order not to penalize interdisciplinary studies which may be essential to a good thesis, up to three of the five required graduate chemistry courses may be advanced undergraduate (9-unit) courses in MCS and/or approved CIT departments. All advanced undergraduate level courses used to satisfy this requirement must be approved by the Director of Undergraduate Studies.

Curriculum - B.S. with Departmental Honors / M.S. in Chemistry

This catalog and the sample schedules presented are intended to be used by students in the first year class entering in the fall of 2015. Upperclass students should refer to the appropriate previous version of the catalog published during their first year for the requirements that are specific to them.

The technical breadth requirement of the MCS core curriculum, starting with the entering class of 2015, requires a minimum of four technical courses outside of the student's primary major. Chemistry majors must at minimum take the following non-chemistry technical courses: 33-111 Physics I for Science Students (to be re-numbered as 33-121 starting in the spring of 2016), 33-122 Physics II for Biological Sciences and Chemistry Students, either 03-121 Modern Biology **or** 03-231 Biochemistry I **or** 03-232 Biochemistry I, 15-110 Principles of Computing (or other approved programming course), 21-120 Differential and Integral Calculus and 21-122 Integration and Approximation **or** 21-124 Calculus II for Biologists and Chemists. Students should complete this technical core as early as possible and preferably by the end of their fifth semester.

The non-technical breadth requirements for MCS students includes 76-101 Interpretation and Argument, four courses with a minimum of 36 units from the arts, humanities or social sciences and a course of at least 9 units from an approved list in the category of Cultural/Global understanding, Three ENGAGE in Wellness courses, one ENGAGE in Service course, one ENGAGE in the Arts course, EUREKA! Discovery and its Impact, the MCS first-year

seminar, and the MCS Junior Seminar for a total of 72 units. For more information on allowed courses, refer to the MCS section of this catalog.

First Year

		Units
Fall		
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
21-120	Differential and Integral Calculus	10
33-111	Physics I for Science Students (to be renumbered as 33-121 starting the spring 2016 semester)	12
or 03-121	Modern Biology	
or 15-110	Principles of Computing	
38-101	EUREKA!: Discovery and Its Impact	6
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
		50

Students interested in majoring in chemistry who have a strong chemistry background, should enroll in 09-107 rather than 09-105. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II.

02-201 Programming for Scientists is an acceptable alternative to 15-110 for chemistry majors as are any upper level courses in programming.

There are some elective laboratory courses offered for MCS students in the first year. These include 03-115 Phage Genomics Research and 09-122 Molecular Tools for Biological and Chemical Studies. The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take 03-121 Modern Biology so that their unit total is lower and they get a start on their required biology courses.

		Units
Spring		
09-106	Modern Chemistry II Chemistry majors who place out of 09-106 can take 09-348 Inorganic Chemistry	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
15-110	Principles of Computing	10
or 33-121	Physics I for Science Students	
or 03-121	Modern Biology	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	9
		48

Sophomore Year

		Units
Fall		
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-201	Undergraduate Seminar I	1
33-122	Physics II for Biological Sciences and Chemistry Students This course is a prerequisite for 09-331, normally taken in the spring of the junior year.	9
09-445	Undergraduate Research	9
xx-xxx	Arts, Humanities and Social Sciences Course 2	9
		50

		Units
Spring		
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-204	Professional Communication Skills in Chemistry	3
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-220	Modern Organic Chemistry II	10
09-348	Inorganic Chemistry	10
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Sciences Course 3	9
		46

Summer

10 weeks Honors Research recommended

Junior Year

		Units
Fall		
09-301	Undergraduate Seminar III	1
09-231	Mathematical Methods for Chemists	9
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-445	Undergraduate Research	9
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Arts, Humanities and Social Sciences Course 4	9
		50

		Units
Spring		
09-302	Undergraduate Seminar IV	1
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-445	Undergraduate Research	6
09-xxx	Graduate Chemistry Course 1 of 5 (see notes on Honors B.S./M.S. electives)	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-331	Modern Analytical Instrumentation	9
38-301	MCS Junior Seminar	6
		52

Summer

10 weeks Honors Research recommended

Senior Year

		Units
Fall		
09-401	Undergraduate Seminar V	1
09-445	Undergraduate Research	9
09-xxx	Graduate Chemistry Course 2 of 5	12
09-xxx	Graduate Chemistry Course 3 of 5	12
xx-xxx	Cultural/Global Understanding	9
38-430	ENGAGE in Wellness: Looking Forward	1
38-110	ENGAGE in Service	1
		45

		Units
Spring		
09-402	Undergraduate Seminar VI	3
09-455	Honors Thesis	15
09-xxx	Graduate Chemistry Course 4 of 5	9
09-xxx	Graduate Chemistry Course 5 of 5	9
38-220	ENGAGE in the Arts	2
xx-xxx	Free Elective	9
		47

Distribution of Units for the B.S. with Departmental Honors/M.S. Degrees

Minimum Total Chemistry Units (241, See distribution below)

		Units
Required Chemistry Courses		
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-204	Professional Communication Skills in Chemistry	3
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10
09-231	Mathematical Methods for Chemists	9
09-331	Modern Analytical Instrumentation	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12

09-321	Laboratory III: Molecular Design and Synthesis	12
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-xxx	Chemistry Seminars	8
		30
09-445	Undergraduate Research (in addition 2 summers recommended)	30
09-xxx	Graduate chemistry courses (see Notes on B.S./M.S. Electives)	51-60
09-455	Honors Thesis	15

Students who transfer into the department and have taken 09-217 Organic Chemistry I, and/or 09-218 Organic Chemistry II, will be required to complete units of 09-435 Independent Study Chemistry, 1 unit per course, under the supervision of the instructor(s) for 09-219 and/or 09-220 in order to master the course content missed in this course sequence.

Chemistry courses required for the BS/MS degree that are numbered 09-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested of and approved by the Director of Undergraduate Studies. In general such requests will be approved only under unusual or extenuating circumstances.

Other Requirements	Units
Biology	9
Computer Science	10
Mathematics	20
Physics	21
Interpretation and Argument	9
Arts, Humanities and Social Sciences courses	36
Cultural/Global Understanding	9
EUREKA! (first year seminar)	6
MCS Junior Seminar	6
ENGAGE in Wellness (3 courses)	3
ENGAGE in Service	1
ENGAGE in the Arts	2
Computing @ Carnegie Mellon	3
Free Electives	3-12
Minimum number of units required for degrees:	388

Free Electives

Free electives are defined as including any course offered by Carnegie Mellon except those in science or engineering fields that are primarily intended for non-majors. A maximum of 9 units total of Physical Education, StuCo and/or ROTC courses combined can be counted as free elective units. The Chemistry Department does not require technical electives.

B.A. in Chemistry

The curriculum for the B.A. degree provides students with the opportunity to take a substantial number of elective and non-technical courses. Certain chemistry, math, and other technical courses required for the B.S. degree are replaced by free electives, making this degree an ideal choice for those who wish to earn an additional major with one of the departments in the College of Humanities and Social Sciences, College of Fine Arts, or with the Business Administration program, though this is not a requirement. It is also attractive for students wishing to pursue careers in dentistry or pharmacy, career paths that require a broader preparation at the undergraduate level and hence more coursework outside of chemistry. Students may earn one or more of the options as described for B.S. degree candidates, providing they complete the courses listed.

The suggested curriculum recommends that the required technical courses be completed at the earliest opportunity, however students have considerable flexibility to postpone these courses in favor of electives, allowing compatibility with the programs of other departments. In designing such programs for a minor or additional major with chemistry, students should note that certain required chemistry courses only are offered in specific semesters, not both. These include the Fall-only courses 09-219 Modern Organic Chemistry, 09-321 Laboratory III: Molecular Design and Synthesis and 09-323 Bioorganic Laboratory and the Spring-only courses 09-214 Physical Chemistry, 09-220 Modern Organic Chemistry II, 09-348 Inorganic Chemistry, and 09-204 Professional Communication Skills in Chemistry. Also, in some cases, a course that is normally scheduled for the fall may be changed to a spring course (or the inverse) due to a departmental curriculum change.

Curriculum - B.A. in Chemistry

This catalog and the sample schedules presented are intended to be used by students in the first year class entering in the fall of 2015. Upperclass students should refer to the appropriate previous version of the catalog published during their first year for the requirements that are specific to them.

The technical breadth requirement of the MCS core curriculum, starting with the entering class of 2015, requires a minimum of four technical courses outside of the student's primary major. Chemistry majors must at minimum take the following non-chemistry technical courses:

Technical Breadth Requirements	Units
33-111 Physics I for Science Students (to be renumbered as 33-121 starting in the spring of 2016)	12
33-122 Physics II for Biological Sciences and Chemistry Students	9
03-121 Modern Biology or 03-231 Biochemistry I or 03-232 Biochemistry I	9
15-110 Principles of Computing - or other approved programming course	10
21-120 Differential and Integral Calculus	10
21-122 Integration and Approximation or 21-124 Calculus II for Biologists and Chemists	10

Students should complete this technical core as early as possible and preferably by the end of their fifth semester.

The non-technical breadth requirements for MCS students includes 76-101 Interpretation and Argument, four courses with a minimum of 36 units from the arts, humanities or social sciences and a course of at least 9 units from an approved list in the category of Cultural/Global understanding, Three ENGAGE in Wellness courses, one ENGAGE in Service course, one ENGAGE in the Arts course, EUREKA! Discovery and its Impact, the MCS first-year seminar, and the MCS Junior Seminar for a total of 72 units. For more information on allowed courses, refer to the MCS section of this catalog.

First Year

Fall	Units
09-105 Introduction to Modern Chemistry I or 09-107 Honors Chemistry: Fundamentals, Concepts and Applications	10
21-120 Differential and Integral Calculus	10
33-111 Physics I for Science Students (to be renumbered 33-121 as of the spring 2016 semester) or 03-121 Modern Biology or 15-110 Principles of Computing	12
76-101 Interpretation and Argument	9
38-101 EUREKA!: Discovery and Its Impact	6
99-101 Computing @ Carnegie Mellon	3
	50

Students interested in majoring in chemistry who have a strong chemistry background, should enroll in 09-107 rather than 09-105. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II.

02-201 Programming for Scientists is an acceptable alternative to 15-110 for chemistry majors as are any upper level courses in programming.

There are some elective laboratory courses offered for MCS students in the first year. These include 03-115 Phage Genomics Research and 09-122 Molecular Tools for Biological and Chemical Studies. The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take an alternate technical course to Physics I such as 15-110 or 03-121 so that their unit total is lower.

Spring	Units
09-106 Modern Chemistry II Chemistry majors who place out of 09-106 can take 09-348 Inorganic Chemistry	10
21-122 Integration and Approximation or 21-124 Calculus II for Biologists and Chemists	10
15-110 Principles of Computing or 33-121 Physics I for Science Students	10

or 03-121	Modern Biology	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	9

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Sophomore Year

Fall		Units
09-201	Undergraduate Seminar I	1
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
33-122	Physics II for Biological Sciences and Chemistry Students This course is required upon graduation.	9
xx-xxx	Arts, Humanities and Social Sciences Course 2	9

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Spring		Units
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-204	Professional Communication Skills in Chemistry (It is recommended that this course be completed prior to taking the junior level labs, 09-321 or 09-323.)	3
09-220	Modern Organic Chemistry II	10
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-214	Physical Chemistry (Students wishing to pursue careers in the health professions may wish to take biochemistry, 03-232, and delay physical chemistry until the junior or senior year spring semester)	9
or 09-348	Inorganic Chemistry	
or 03-232	Biochemistry I	
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Sciences Course 3	9

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Junior Year

Fall		Units
09-301	Undergraduate Seminar III	1
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
03-121	Modern Biology	9
or 15-110	Principles of Computing	
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Arts, Humanities and Social Sciences Course 4	9
xx-xxx	Free Elective	9

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Spring		Units
09-302	Undergraduate Seminar IV	1
09-348	Inorganic Chemistry	10
or 09-214	Physical Chemistry	
09-xxx	Chemistry Elective (See notes below regarding chemistry electives.)	9
38-301	MCS Junior Seminar	6
xx-xxx	Cultural/Global Understanding Requirement	9
xx-xxx	Free Elective	9

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Senior Year

Fall		Units
09-401	Undergraduate Seminar V	1
09-xxx	Chemistry Elective	9
38-430	ENGAGE in Wellness: Looking Forward	1
38-110	ENGAGE in Service	1
xx-xxx	Free Electives	34

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Spring		Units
09-402	Undergraduate Seminar VI	3

38-220	ENGAGE in the Arts	2
xx-xxx	Free Electives	40

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Distribution of Units for the B.A. in Chemistry

Minimum Total Chemistry Units 124; See distribution below:

Required Chemistry Courses	Units
09-105 Introduction to Modern Chemistry I	10
or 09-107 Honors Chemistry: Fundamentals, Concepts and Applications	
09-106 Modern Chemistry II	10
09-204 Professional Communication Skills in Chemistry	3
09-219 Modern Organic Chemistry	10
09-220 Modern Organic Chemistry II	10
09-214 Physical Chemistry	9
or 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	
or 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	
09-348 Inorganic Chemistry	10
09-221 Laboratory I: Introduction to Chemical Analysis	12
09-222 Laboratory II: Organic Synthesis and Analysis	12
09-321 Laboratory III: Molecular Design and Synthesis	12
or 09-323 Bioorganic Chemistry Laboratory	
09-xxx Chemistry Seminars	8
09-xxx Chemistry Electives	18

09-322 Laboratory IV: Molecular Spectroscopy and Dynamics may be taken in lieu of 09-321 Laboratory III: Molecular Design and Synthesis or 09-323 Bioorganic Chemistry Laboratory. However the student must complete the necessary pre- and co-requisites of 09-231, 09-344, 09-331 and 09-345. In this case 09-331 and 09-344 will count as chemistry electives towards the B.A. degree.

Students who transfer into the department and have taken 09-217 Organic Chemistry I, and/or 09-218 Organic Chemistry II, will be required to complete units of 09-435 Independent Study Chemistry, 1 unit per course, under the supervision of the instructor(s) for 09-219 and/or 09-220 in order to master the course content missed in this course sequence.

Chemistry courses required for the B.A. degree that are numbered 09-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested of and approved by the Director of Undergraduate Studies. In general such requests will be approved only under unusual or extenuating circumstances.

Other Requirements	Units
Biology (either Modern Biology or Biochemistry)	9
Computer Science	10
Mathematics	20
Physics	21
Interpretation and Argument	9
Arts, Humanities and Social Sciences courses	36
Cultural/Global Understanding	9
EUREKA! (First year seminar)	6
MCS Junior Seminar	6
ENGAGE in Wellness (3 courses)	3
ENGAGE in Service	1
ENGAGE in the Arts	2
Computing @ Carnegie Mellon	3
Free Electives	101
Minimum number of units for the degree	360

The above B.A. curriculum recommends a range of 40-50 units per semester. The total units actually taken may exceed the 360 unit minimum, but students are strongly encouraged to take the extra elective courses in whatever subjects they wish in order to enrich their backgrounds and enhance their educational experience.

Notes on Electives

Chemistry Electives

A minimum of 18 units of chemical electives is required.

Chemical electives can be satisfied by 09-445 Undergraduate Research, or by most other chemistry courses 09-3xx or higher, undergraduate or graduate, for which the student has the necessary prerequisites, or by 03-231/03-232 Biochemistry I. Biochemistry also fulfills the Life Sciences requirement for the MCS technical breadth requirement. 09-435 Independent Study Chemistry, may only be used to fulfill this requirement with permission of the Director of Undergraduate Studies. Certain interdisciplinary courses (e.g. 39-xxx) relating to chemistry can also be used with permission by the Director of Undergraduate Studies. The scheduling of these electives can vary and students should check with the department offering the course to see which courses are offered in any given year or semester and with the Director of Undergraduate Studies in the Department of Chemistry to ascertain whether the course is an acceptable chemistry elective.

Free Electives

Free electives are defined as including any course offered by Carnegie Mellon except those in science or engineering fields that are primarily intended for non-majors. A maximum of 9 units total of Physical Education and/or ROTC courses combined can be counted as free elective units. The Chemistry Department does not require technical electives.

Requirements for a Minor in Chemistry

In order for a student to receive a minor in Chemistry in conjunction with a B.S. or B.A. degree from another (primary) department, the successful completion of six courses as distributed below is required. Students pursuing the minor must inform the Chemistry Department of their intentions in writing using the MCS form for declaration of a minor so that the minor designation can be approved prior to graduation. The form may be obtained in the department office, DH 1317 or from the MCS undergraduate web page, <http://www.cmu.edu/mcs/undergrad/advising/forms/index.html>. **It should be completed and submitted to the department office, DH 1317, no later than the end of the course add period of the final semester prior to graduation.** If you decide at a later date not to complete the minor, it would be helpful to notify the Director of Undergraduate Studies, ks01@andrew.cmu.edu, so that it can be removed from your record. Minors are listed on the transcript but not on the diploma.

Note: An introductory chemistry class equivalent to either 09-105 Introduction to Modern Chemistry I or 09-107 Honors Chemistry: Fundamentals, Concepts and Applications is a presumed prerequisite to beginning the minor in chemistry.

A. Four Required Core Courses

09-106	Modern Chemistry II	10
09-221	Laboratory I: Introduction to Chemical Analysis	9-12
or 09-207	Techniques in Quantitative Analysis	
09-217	Organic Chemistry I	9-10
or 09-219	Modern Organic Chemistry	
Choice of one of the following courses:		
09-214	Physical Chemistry	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-347	Advanced Physical Chemistry	12
09-348	Inorganic Chemistry	10

Courses in this group that are not used to satisfy Part A core courses may be used to satisfy elective course requirements in part B below, if they are **not** required by the student's primary department. However the only combination of physical chemistry courses (09-344, 09-345, 09-347 and 09-214) that is allowed is 09-344 and 09-345.

Enrollment in 09-347 is only open to students majoring in chemical engineering.

B. Two Elective Courses from the following list.

09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
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or 09-214	Physical Chemistry	
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-222	Laboratory II: Organic Synthesis and Analysis	9-12
or 09-208	Techniques for Organic Synthesis and Analysis	
09-218	Organic Chemistry II	9-10
or 09-220	Modern Organic Chemistry II	
03-231/232	Biochemistry I	9
09-xxx	Approved Upper Level Chemistry Course (must be 09-3xx or higher but see exclusions noted below)	

Courses in this section (part B above) can not be counted toward the minor if they are required in any way by the student's primary department or towards an additional major or minor other than as a free elective. For example, students majoring in Biological Sciences can not double count 03-231 (or 03-232), 09-208 (or 09-222), or 09-218 (or 09-220) toward the elective courses for the minor in chemistry. Chemical engineering majors can not count 03-231 (or 03-232) or a chemistry course that is used to satisfy that department's required chemistry or advanced chem/biochem elective. Also, chemical engineering majors can not use 09-344, 09-345 or 09-214 due to the similarity of these courses to 09-347 Advanced Physical Chemistry, which is required by the chemical engineering department.

09-231 Mathematical Methods for Chemists, does not count towards the minor in chemistry. The undergraduate research courses 09-445 Undergraduate Research and 09-435 Independent Study Chemistry cannot be used for the minor.

Transfer credit will be accepted only for the prerequisite 09-105, 09-106 and 09-217. All other classes towards the chemistry minor must be completed at Carnegie Mellon University.

Transfer Credit for Chemistry Courses

1. Requests for transfer credit for chemistry classes taken at other institutions should be made to Karen Stump, the Director of Undergraduate Studies in the Department of Chemistry. Students making such requests should follow the policies and procedures in place within their home colleges in assembling materials for such requests. Consult with your advisor on the appropriate steps.
2. At minimum requests must be accompanied by a complete syllabus including the textbook that will be used, a detailed list of topic areas and an indication of whether or not the course is part of the curriculum for science majors at the other institution.
3. No transfer credit will be awarded for the laboratory classes required for the chemistry or biology major at Carnegie Mellon University, 09-207, 09-221, 09-208, 09-222, 09-321, 09-323 and 09-322. Requests for transfer credit for 09-101, Introduction to Experimental Chemistry, will be accepted with the appropriate documentation.
4. In assessing the suitability of courses for transfer credit, the following factors are considered:
 - The rigor of the course must be comparable to that offered at Carnegie Mellon. This is usually assessed via the textbook used and the amount of time spent on topic areas.
 - The topic areas should match to a degree of at least 80% those covered in the comparable course at Carnegie Mellon University.
5. 09-105 Introduction to Modern Chemistry I focuses primarily on structure and bonding. Detailed topics include the following:
 - History and Conceptual Basis of Modern Chemistry
 - Radiation, Quantum Mechanics, and Atomic Structure
 - Periodic Table and Trends in Elemental Properties (including discussion of exceptions to trends)
 - Bonding (bond polarity)
 - Lewis Structures (octet rule and exceptions; formal charge)
 - Resonance Structures
 - Molecular shapes
 - Molecular Polarity
 - Naming compounds
 - Interparticle (intermolecular) forces and comparing physical properties from them
 - Valence Bond (Localized Electron) and Molecular Orbital Theory
 - Determining number of moles and chemical formulas

- Writing and balancing chemical equations (in particular completing combustion and double displacement reactions – including acid-base and precipitation reactions)
 - Stoichiometry – limiting reactant and percentage yield
 - Gases (mainly ideal) and stoichiometric applications involving them
 - Phase transitions
 - Solutions (determining concentrations, dilution problems, stoichiometric applications, application of solubility rules to determine if a precipitate forms)
 - Acid-base reactions and titrations
 - Oxidations Numbers and Redox Reactions/Titrations (including balancing redox reactions)
 - Colligative Properties; Mixtures and Distillation
 - Transition Metal Complexes and Crystal Field Theory (including crystal field stabilization energy and optical properties)
6. 09-106 Modern Chemistry II focuses primarily on thermodynamics, kinetics and equilibrium. Detailed topic areas include the following.
- Thermochemistry and Thermodynamics (First, Second, and Third Laws, with gas expansion/compression applications, including reversible, adiabatic processes)
 - Internal energy, enthalpy, entropy, Gibbs Free energy, and determination of spontaneity
 - Kinetics : Determination of rate, order, rate laws (including application of pseudo-rate laws, application of integrated rate law to determine order, relationship between time and amount in a reaction, and half-life
 - Reaction mechanisms – applying fast equilibrium and steady-state approximations to determine rate law consistent with mechanism
 - Chemical Equilibrium : determination of Q and K expressions, determination of direction in which reaction proceeds to achieve equilibrium (using Q and Le Chatelier's principles, quantitative calculations to determine K or amounts at various stages, dependence of K on temperature, relationship between Gibbs Free energy, Q, and K)
 - Acid-Base Equilibria: writing dissociation equilibrium reactions and acid-base "neutralization" reactions, autoionization of water (determination of pH and pOH, use of K_w), writing K_a and K_b expressions from dissociation equilibria, quantitative equilibrium calculations for weak acids and bases, titrations between strong species, strong-weak species, and weak-weak species, buffers (calculations of pH and amounts, including how to make a buffer), polyprotic species (quantitative applications and titrations), solubility and precipitation equilibria, determination of K_{sp} expressions and quantitative applications of those expressions, complex ion formation equilibria, emphasis is placed on equilibrium problems that involve multiple types of simultaneous equilibria
 - Electrochemistry: Electrochemical cell notation and writing half-reactions from it, Faraday constant to connect number of moles of electrons / reaction amounts with current, connection of Gibbs Free Energy to cell voltage (potential) at equilibrium and non-equilibrium conditions, determination of K 's (acid-base, solubility constants) or amounts using Nernst equation in concentration cells (K for cell reaction)

Faculty

CATALINA ACHIM, Professor of Chemistry – Ph.D., Carnegie Mellon; Carnegie Mellon, 2001–.

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STEFAN BERNHARD, Professor of Chemistry – Ph.D., University of Fribourg (Switzerland); Carnegie Mellon, 2009–.

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REBECCA FREELAND, Associate Dean for Special Projects, Mellon College of Science and Associate Head, Department of Chemistry – Ph.D., Carnegie Mellon; Carnegie Mellon, 1993–.

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MAUMITA MANDAL, Assistant Professor of Chemistry – Ph.D., Center for Cellular and Molecular Biology (India); Carnegie Mellon, 2008–.

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ECKARD MÜNCK, Professor of Chemistry – Ph.D., Technical University of Darmstadt, (Germany); Carnegie Mellon, 1990–.

TERRANCE B. MURPHY, Teaching Professor at Carnegie Mellon University-Qatar – Ph.D., University of Washington; Carnegie Mellon, 2008–.

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HUNAID NULWALA, Assistant Research Professor – Ph.D., University of California at Santa Barbara; Carnegie Mellon, 2013–.

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GLORIA SILVA, Assistant Teaching Professor – Ph.D., Universidad Nacional de Córdoba (Argentina); Carnegie Mellon, 2002–.

KAREN H. STUMP, Teaching Professor and Director of Undergraduate Studies and Laboratories – M.S., Carnegie Mellon University; Carnegie Mellon, 1983–.

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DAVID YARON, Professor of Chemistry – Ph.D., Harvard University; Carnegie Mellon, 1992–.

Emeriti

GUY C. BERRY, University Professor of Chemistry and Polymer Science, Emeritus – Ph.D., University of Michigan; Carnegie Mellon, 1960–.

AKSEL A. BOTHNER-BY, Professor of Chemistry, Emeritus - Ph.D., Harvard University; Carnegie Mellon, 1958-.

ALBERT A. CARETTO JR., Professor of Chemistry, Emeritus - Ph.D., University of Rochester; Carnegie Mellon, 1959-.

JOSEF DADOK, Professor of Chemical Instrumentation, Emeritus - Ph.D., Czechoslovak Academy of Sciences; Carnegie Mellon, 1967-.

PAUL J. KAROL, Professor of Chemistry - Ph.D., Columbia University; Carnegie Mellon, 1969-.

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Adjunct Faculty

COLIN HORWITZ, Adjunct Research Professor of Chemistry and Chief Technology Officer, GreenOx Catalysts and Deputy Director, Institute for Green Science - Ph.D., Northwestern University; Carnegie Mellon, 1993-.

JOHN PETERSON MYERS, CEO and Chief Scientist of Environmental Health Sciences - Ph.D., University of California at Berkeley; Carnegie Mellon, 2010-.

Courtesy

MICHAEL BOCKSTALLER, Professor of Materials Science Engineering and Faculty of Chemistry - Ph.D., Johannes Gutenberg University (Germany); Carnegie Mellon, 2005-.

ALEX EVILEVITCH, Associate Professor of Physics and Faculty of Chemistry - Ph.D., Lund University; Carnegie Mellon, 2009-.

ANDREW GELLMAN, Thomas Lord Professor of Chemical Engineering, Professor of Materials Science Engineering and Chemistry; Co-Director W.E. Scott Institute for Energy Innovation - Ph.D., University of California, Berkeley; Carnegie Mellon, 1992-.

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LYNN WALKER, Professor of Chemical Engineering and Faculty of Chemistry and Materials Science Engineering - Ph.D., University of Delaware; Carnegie Mellon, 1997-.

JOHN L. WOOLFORD JR., Professor of Biological Sciences; Co-Director of CNASt and Faculty of Chemistry - Ph.D., Duke University; Carnegie Mellon, 1979-.

Department of Mathematical Sciences

Thomas Bohman, Department Head
 William J. Hrusa, Associate Head
 John F. Mackey, Associate Head
 Office: Wean Hall 6113
<http://www.math.cmu.edu>

Mathematics provides much of the language and quantitative underpinnings of the natural and social sciences, and mathematical scientists have been responsible for the development of many of the most commonly used tools in business management as well as for laying the foundation for computational and computer science. The name of the Department of Mathematical Sciences reflects its tradition of outstanding research and teaching of applicable mathematics relating to these areas. Indeed, the Department contains highly ranked research groups in Applied Mathematics, Discrete Mathematics, Logic, and Mathematical Finance. These research strengths are reflected in the variety of options that the Department provides for its undergraduate majors.

The Department offers a B.S. degree in Mathematical Sciences with concentrations in Mathematics, Operations Research and Statistics, Statistics, Discrete Mathematics and Logic, and Computational and Applied Mathematics.

The B.S. in Mathematics Curriculum is the least structured of our programs, in recognition of the wide variety of interests that can be productively coupled with the study of mathematical sciences. It can be an appropriate choice for students planning for graduate study in mathematics or seeking to design their curriculum to take advantage of the many opportunities for a second major from another department in the University.

The Operations Research and Statistics Concentration prepares students to enter the area of operations research, which is expected to be among the growth occupations over the next decade. Mathematicians with a background in operations research are especially valuable in such diverse activities as project planning, production scheduling, market forecasting and finance. Such applications are found in virtually all industrial and governmental settings.

The Statistics Concentration prepares students to contribute to a wide variety of research areas. Applications range from experimental design and data analysis in the physical and social sciences, medicine and engineering, to modeling and forecasting in business and government, to actuarial applications in the financial and insurance industries. This is also a useful second major for students planning for graduate study and research in subject areas requiring a strong statistical background.

The Discrete Mathematics and Logic Concentration provides a background in discrete mathematics, mathematical logic, and theoretical computer science. This concentration prepares the student to do research in these and related fields, or to apply their ideas elsewhere.

Finally, the Computational and Applied Mathematics Concentration provides the background needed to support the computational and mathematical analysis needs of a wide variety of businesses and industries and is well suited to students with an interest in the physical sciences and engineering.

The Department places great emphasis on the advising of students. This is critical if students are to make the most of their years at the University. Students are urged to work carefully with their advisor and other faculty to formulate their degree programs. Study abroad is encouraged, and an interested student should investigate the opportunities available in the Undergraduate Options section of the catalog.

Special options within the Department

The Department offers special opportunities for the exceptionally well-prepared and intellectually ambitious student. These options are available to students from any department in the University.

Matrix Theory and Vector Analysis

For selected Freshmen entering the University, we offer the Fall/Spring sequence of 21-242 Matrix Theory and 21-269 Vector Analysis, which include a rigorous introduction to proofs and abstract mathematics. Typically, a student choosing this sequence has mastered the operational aspects of high school mathematics and now seeks a deeper conceptual understanding.

Mathematical Studies

Following the 21-242/21-269 sequence, we offer Mathematical Studies Analysis I/II and Mathematical Studies Algebra I/II. These courses provide excellent preparation for graduate study, with many of the participants taking graduate courses as early as their Junior year. The typical enrollment of about 15 students allows for close contact with faculty. Admission to Mathematical Studies is by invitation, and interested students should apply during the Spring of their Freshman year.

Honors Degree Program

This demanding program qualifies the student for two degrees: The Bachelor of Science and the Master of Science in Mathematical Sciences. This program typically includes the Mathematical Studies option. For students who complete the Mathematical Studies sequence, the Master of Science degree in Mathematical Sciences may be earned together with a Bachelor of Science from another department.

Interdisciplinary Programs

Several interdisciplinary options enable a student to combine mathematics with other disciplines.

- The Bachelor of Science and Arts (p. 105) program allows a student to combine mathematics with study in any of the five schools in the College of Fine Arts.
- The Science and Humanities Scholars (p. 86) program includes an option shared with the Statistics Department in the Humanities and Social Sciences College that leads to a BS in Mathematics and Statistics.
- The Bachelor of Science in Mathematics and Economics (p. 386) is a flexible program which allows students to develop depth in both fields of study. Note: for students whose home college is Dietrich College, this major is known as the Bachelor of Science in Economics and Mathematical Sciences.
- Finally, a joint program with the Heinz College of Public Policy and Management and the Tepper School of Business leads to the degree Bachelor of Science in Computational Finance (<http://coursecatalog.web.cmu.edu/servicesandoptions/intercollegeprograms/#bachelorofscienceincomputationalfinance>). (p. 77)

Curricula

For each concentration, we provide a list of the requirements and a suggested schedule that takes prerequisites into account. A Mathematical Sciences, Computer Science, Physics, Statistics Elective refers to any course from the Departments of Mathematical Sciences, Computer Science, Physics, Statistics, respectively, satisfying the following restrictions: a mathematical sciences course must be at the 21-300 level or above or 21-270 or 21-292, a computer science course must be at the 15-200 level or above, a physics course must be at the 33-300 level or above, and a statistics course must have at least 36-225 as a prerequisite.

Mathematical Sciences majors are required to complete an introductory computer science course, either 15-110 or 15-112. Students who plan to take further computer science courses must complete 15-112.

An H&SS Elective refers to a course in the Dietrich College of Humanities and Social Sciences requirements as described in the catalog section for the Mellon College of Science. A course listed as an Elective is a free elective with the only restriction that the maximum total of ROTC, STUCO, and Physical Education units that will be accepted for graduation is nine.

For a list of courses required for all MCS students see "First Year for Science Students." (p.)

Mathematics Degree

This program is the most flexible available to our majors. The flexibility to choose eight electives within the major plus seven humanities courses and seven free electives allows the student to design a program to suit his or her individual needs and interests. The requirements for the Mathematics Degree are:

Mathematical Sciences Courses (required)

The alternative courses 21-242, 21-261, and 21-268 (or 21-269) are particularly recommended for a student planning to pursue graduate work.

Courses	Units	
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
36-225	Introduction to Probability Theory	9
or 21-325	Probability	
21-259	Calculus in Three Dimensions	9
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9
or 21-261	Introduction to Ordinary Differential Equations	
or 33-231	Physical Analysis	
21-341	Linear Algebra	9
21-355	Principles of Real Analysis I	9
21-356	Principles of Real Analysis II	9
21-373	Algebraic Structures	9

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Forty-five units of (required) Mathematical Sciences electives (at the 21-300 level or above or 21-270 or 21-292).

27 Units of (required) Mathematical Sciences (at the 21-300 level or above or 21-270 or 21-292, or Computer Science (at the 15-200 level or above), or Physics (at the 33-300 level or above), or Statistics (must have at least 36-225 as a prerequisite) electives.

MCS General Education (required)

MCS or SHS humanities, social sciences, and science core (114 units)

Mathematical Sciences Electives for Students Intending Graduate Studies

Students preparing for graduate study in mathematics should consider the following courses as Mathematical Sciences electives, choosing among them according to the desired area of graduate study:

21-301	Combinatorics	9
21-371	Functions of a Complex Variable	9
21-372	Partial Differential Equations and Fourier Analysis	9
21-374	Field Theory	9
21-441	Number Theory	9
21-465	Topology	9
21-467	Differential Geometry	9
21-470	Selected Topics in Analysis	9
21-476	Introduction to Dynamical Systems	9
21-484	Graph Theory	9
21-600	Mathematical Logic I	12
21-602	Introduction to Set Theory I	12
21-603	Model Theory I	12
21-610	Algebra I	12
21-620	Real Analysis	6
21-621	Introduction to Lebesgue Integration	6
21-630	Ordinary Differential Equations	12
21-640	Introduction to Functional Analysis	12
21-651	General Topology	12
21-660	Introduction to Numerical Analysis I	12
21-701	Discrete Mathematics	12
21-720	Measure and Integration	12
21-721	Probability	12
21-737	Probabilistic Combinatorics	12
21-738	Extremal Combinatorics	12

Note that courses 21-600 and above carry graduate credit. Courses at the 600 level are designed as transitional courses to graduate study. A student preparing for graduate study should also consider undertaking independent work. The Department offers 21-499 Undergraduate Research Topic and 21-599 Undergraduate Reading and Research for this purpose.

Courses 21-700 and above can be used with the permission of both the instructor and the department.

Suggested Schedule for students without ap credit

Freshman Year

Fall	Units	
21-120	Differential and Integral Calculus	10
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
38-101	First-year Seminar	6
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
xx-xxx	Life/Physical Sciences Course	9
		47

Spring	Units	
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
21-122	Integration and Approximation	10
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
xx-xxx	Physical/Life Sciences Course	9
xx-xxx	H&SS Elective	9
		48

Sophomore Year

Fall	Units	
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
21-268	Multidimensional Calculus	10
xx-xxx	STEM Course	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9
		46

Spring	Units	
21-261	Introduction to Ordinary Differential Equations	10
21-373	Algebraic Structures	9
xx-xxx	Mathematical Sci, Statistics, or Computer Sci Elective	9
xx-xxx	STEM Course	9
xx-xxx	H&SS Elective	9
		46

Junior Year

Fall	Units	
21-355	Principles of Real Analysis I	9
36-225	Introduction to Probability Theory	9
or 21-325	Probability	
xx-xxx	Mathematical Sci, Statistics, or Computer Sci Elective	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9
		45

Spring	Units	
21-341	Linear Algebra	9
21-356	Principles of Real Analysis II	9
21-xxx	Mathematical Sciences Elective	9
xx-xxx	Cultural/Global Understanding Elective	9
xx-xxx	Free Elective	9
		45

Senior Year

Fall		Units
21-xxx	Mathematical Sciences Elective	9
21-xxx	Mathematical Sciences Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9

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Spring		Units
21-xxx	Mathematical Sciences Elective	9
21-xxx	Mathematical Sciences Elective	9
xx-xxx	Mathematical Sci, Statistics, or Computer Sci Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9

45**360 Minimum number of units for the degree:****Suggested Schedule for Students with AP Credit**

Freshman Year

Fall		Units
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
38-101	First-year Seminar	6
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
xx-xxx	Life/Physical Sciences Course	9

47

Spring		Units
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
21-268	Multidimensional Calculus	10
or 21-269	Vector Analysis	
xx-xxx	Mathematical Sci, Statistics, or Computer Sci Elective	9
xx-xxx	Physical/Life Sciences Course	9
xx-xxx	H&SS Elective	9

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Sophomore Year

Fall		Units
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
36-225	Introduction to Probability Theory	9
or 21-325	Probability	
xx-xxx	STEM Course	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9

45

Spring		Units
21-261	Introduction to Ordinary Differential Equations	10
21-373	Algebraic Structures	9
xx-xxx	Mathematical Sci, Statistics, or Computer Sci Elective	9
xx-xxx	STEM Course	9
xx-xxx	H&SS Elective	9

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Junior Year

Fall		Units
21-355	Principles of Real Analysis I	9
21-xxx	Mathematical Sciences Elective	9

xx-xxx	Mathematical Sci, Statistics, or Computer Sci Elective	9
xx-xxx	Cultural/Global Understanding Course	9
xx-xxx	Free Elective	9

45

Spring		Units
21-341	Linear Algebra	9
21-356	Principles of Real Analysis II	9
21-xxx	Mathematical Sciences Elective	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9

45

Senior Year

Fall		Units
21-xxx	Mathematical Sciences Elective	9
21-xxx	Mathematical Sciences Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9

45

Spring		Units
21-xxx	Mathematical Sciences Elective	9
21-xxx	Mathematical Sciences Elective	9
xx-xxx	Mathematical Sci, Statistics, or Computer Sci Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9

45**Minimum number of units for the degree: 360****Operations Research and Statistics Concentration**

An operations research professional employs quantitative and computational skills toward enhancing the function of an organization or process. Students choosing this concentration will develop problem-solving abilities in mathematical and statistical modeling and computer-based simulation in areas such as network design, transportation scheduling, allocation of resources and optimization. In addition to courses in mathematics and statistics, a basic background in economics and accounting is included. Since problems in business and industry are often solved by teams, the program also includes a group project to be undertaken in the Senior year. Students choosing this concentration may not pursue an additional major or minor in Statistics in the Humanities and Social Sciences College.

The requirements for the concentration in Operations Research and Statistics are:

Mathematical Sciences Courses (required)

The alternative courses 21-242, 21-261, and 21-268 (or 21-269) are particularly recommended for a student planning to pursue graduate work.

Courses		Units
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
21-259	Calculus in Three Dimensions	9
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9
or 21-261	Introduction to Ordinary Differential Equations	
or 33-231	Physical Analysis	
21-292	Operations Research I	9

21-369	Numerical Methods	9
21-393	Operations Research II	9
		94

Statistics Courses (required)

Courses		Units
36-225	Introduction to Probability Theory	9
or 21-325	Probability	
36-226	Introduction to Statistical Inference	9
36-401	Modern Regression	9
36-402	Advanced Methods for Data Analysis	9
36-410	Introduction to Probability Modeling	9
		45

Economics, Business, and Computer Science Courses (required)

Courses		Units
15-110	Principles of Computing	10
70-122	Introduction to Accounting	9
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
		46

Depth Electives (required)

Five depth electives (required), to be chosen from the list below. The course 21-355 is particularly recommended for a student planning to pursue graduate work.

15-122	Principles of Imperative Computation	10
15-150	Principles of Functional Programming	10
15-210	Parallel and Sequential Data Structures and Algorithms	12
21-270	Introduction to Mathematical Finance	9
21-301	Combinatorics	9
21-341	Linear Algebra	9
21-355	Principles of Real Analysis I	9
21-356	Principles of Real Analysis II	9
21-365	Projects in Applied Mathematics	9
21-366	Topics in Applied Mathematics	9
21-370	Discrete Time Finance	9
21-373	Algebraic Structures	9
21-377	Monte Carlo Simulation for Finance	9
21-378	Mathematics of Fixed Income Markets	9
21-420	Continuous-Time Finance	9
21-484	Graph Theory	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9
70-371	Operations Management	9
70-460	Mathematical Models for Consulting	9
70-471	Supply Chain Management	9

MCS General Education (required)

MCS or SHS humanities, social sciences, and science core (114 units)

Note that 73-100, 73-230, and 73-240 satisfy requirements from the MCS general education core.

Suggested Schedule

Freshman Year

Fall		Units
21-120	Differential and Integral Calculus	10
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
38-101	First-year Seminar	6

76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
xx-xxx	Life/Physical Sciences Course	9
		47

Spring		Units
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
21-122	Integration and Approximation	10
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
xx-xxx	Physical/Life Sciences Course	9
xx-xxx	H&SS Elective	9
		48

Sophomore Year

Fall		Units
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
21-259	Calculus in Three Dimensions	9
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
73-100	Principles of Economics	9
xx-xxx	STEM Course	9
		36

Spring		Units
21-260	Differential Equations	9
or 21-261	Introduction to Ordinary Differential Equations	
or 33-231	Physical Analysis	
21-292	Operations Research I	9
70-122	Introduction to Accounting	9
xx-xxx	H&SS Elective	9
xx-xxx	STEM Elective	9
		45

Junior Year

Fall		Units
21-369	Numerical Methods	9
36-225	Introduction to Probability Theory	9
or 21-325	Probability	
73-230	Intermediate Microeconomics	9
xx-xxx	Depth Elective	9
xx-xxx	Free Elective	9
		45

Spring		Units
36-226	Introduction to Statistical Inference	9
36-410	Introduction to Probability Modeling	9
73-240	Intermediate Macroeconomics	9
xx-xxx	Depth Elective	9
xx-xxx	Cultural/Global Understanding Course	9
		45

Senior Year

Fall		Units
21-393	Operations Research II	9
36-401	Modern Regression	9
xx-xxx	Depth Elective	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9
		45

Spring		Units
36-402	Advanced Methods for Data Analysis	9
xx-xxx	Depth Elective	9
xx-xxx	Depth Elective	9
xx-xxx	H&SS Elective	9

xx-xxx Free Elective 9

45

Minimum number of units for the degree: 360

Statistics Concentration

Statistics is concerned with the process by which inferences are made from data. Statistical methods are essential to research in a wide variety of scientific disciplines. For example, principles of experimental design that assist chemists in improving their yields also help poultry farmers grow bigger chickens. Similarly, time series analysis is used to better understand radio waves from distant galaxies, hormone levels in the blood, and concentrations of pollutants in the atmosphere. This diversity of application is an exciting aspect of the field, and it is one reason for the current demand for well-trained statisticians.

The courses 36-225 Introduction to Probability Theory and 36-226 Introduction to Statistical Inference taken in the Junior year serve as the basis for all further statistics courses. The course 21-325 is a more mathematical alternative to 36-225.

The Statistics Concentration is jointly administered by the Department of Mathematical Sciences and the Department of Statistics. The Department of Statistics considers applications for the master's program from undergraduates in the Junior year. Students who are accepted are expected to finish their undergraduate studies, using some electives in the Senior year to take courses recommended by the Department of Statistics. This will ensure a strong background to permit completion of the master's program in one year beyond the baccalaureate. The requirements for the Statistics Concentration are:

Mathematical Sciences Courses (required)

The alternative courses 21-242, 21-261, and 21-268 (or 21-269) are particularly recommended for a student planning to pursue graduate work.

Courses	Units
21-120 Differential and Integral Calculus	10
21-122 Integration and Approximation	10
21-127 Concepts of Mathematics	10
or 21-128 Mathematical Concepts and Proofs	
21-228 Discrete Mathematics	9
or 15-251 Great Theoretical Ideas in Computer Science	
21-241 Matrices and Linear Transformations	10
or 21-242 Matrix Theory	
21-259 Calculus in Three Dimensions	9
or 21-268 Multidimensional Calculus	
or 21-269 Vector Analysis	
21-260 Differential Equations	9
or 21-261 Introduction to Ordinary Differential Equations	
or 33-231 Physical Analysis	
21-292 Operations Research I	9
21-369 Numerical Methods	9
21-393 Operations Research II	9
	94

Statistics Courses (required)

Courses	Units
36-225 Introduction to Probability Theory	9
or 21-325 Probability	
36-226 Introduction to Statistical Inference	9
36-401 Modern Regression	9
36-402 Advanced Methods for Data Analysis	9
36-410 Introduction to Probability Modeling	9
	45

Economics and Computer Science Courses (required)

Courses	Units
15-112 Fundamentals of Programming and Computer Science	12
15-122 Principles of Imperative Computation	10
73-100 Principles of Economics	9
	31

Depth Electives (required)

Four depth electives, including at least one statistics course, to be chosen from the list below. The course 21-355 Principles of Real Analysis I is particularly recommended for a student planning to pursue graduate work.

15-150 Principles of Functional Programming	10
15-210 Parallel and Sequential Data Structures and Algorithms	12
21-270 Introduction to Mathematical Finance	9
21-341 Linear Algebra	9
21-355 Principles of Real Analysis I	9
21-356 Principles of Real Analysis II	9
21-365 Projects in Applied Mathematics	9
21-366 Topics in Applied Mathematics	9
21-370 Discrete Time Finance	9
21-373 Algebraic Structures	9
21-377 Monte Carlo Simulation for Finance	9
21-378 Mathematics of Fixed Income Markets	9
21-420 Continuous-Time Finance	9
21-484 Graph Theory	9
36-461 Special Topics: Statistical Methods in Epidemiology	9
36-462 Special Topics: Data Mining	9
36-463 Special Topics: Multilevel and Hierarchical Models	9
36-464 Special Topics: Applied Multivariate Methods	9

MCS General Education (required)

MCS or SHS humanities, social sciences, and science core (114 units)

Note that 73-100 satisfies the requirement from the MCS core.

Suggested Schedule

Freshman Year

Fall	Units
21-120 Differential and Integral Calculus	10
21-127 Concepts of Mathematics	10
or 21-128 Mathematical Concepts and Proofs	
38-101 First-year Seminar	6
76-101 Interpretation and Argument	9
99-101 Computing @ Carnegie Mellon	3
xx-xxx Life/Physical Sciences Course	9
	47

Spring

Spring	Units
15-112 Fundamentals of Programming and Computer Science	12
21-122 Integration and Approximation	10
21-241 Matrices and Linear Transformations	10
or 21-242 Matrix Theory	
xx-xxx STEM Course	9
xx-xxx Physical/Life Sciences Course	9
	50

Sophomore Year

Fall	Units
21-228 Discrete Mathematics	9
or 15-251 Great Theoretical Ideas in Computer Science	
21-259 Calculus in Three Dimensions	9
or 21-268 Multidimensional Calculus	
or 21-269 Vector Analysis	
73-100 Principles of Economics	9
xx-xxx STEM Course	9
xx-xxx H&SS Elective	9
	45

Spring

Spring	Units
15-122 Principles of Imperative Computation	10
21-260 Differential Equations	9

or 21-261	Introduction to Ordinary Differential Equations	
or 33-231	Physical Analysis	
21-292	Operations Research I	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9
		46

Junior Year

Fall		Units
21-369	Numerical Methods	9
36-225	Introduction to Probability Theory	9
or 21-325	Probability	
xx-xxx	Depth Elective	9
xx-xxx	Depth Elective	9
xx-xxx	H&SS Elective	9
		45

Spring		Units
36-226	Introduction to Statistical Inference	9
36-410	Introduction to Probability Modeling	9
xx-xxx	Depth Elective	9
xx-xxx	Cultural/Global Understanding Course	9
xx-xxx	Free Elective	9
		45

Senior Year

Fall		Units
21-393	Operations Research II	9
36-401	Modern Regression	9
xx-xxx	Depth Elective	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9
		45

Spring		Units
36-402	Advanced Methods for Data Analysis	9
xx-xxx	Depth Elective	9
xx-xxx	Depth Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
		45

360 Minimum number of units required for the degree:

Discrete Mathematics and Logic Concentration

Discrete mathematics is the study of finite and countable structures and algorithms for the manipulation and analysis of such structures, while mathematical logic is the study of axiomatic systems and their mathematical applications. Both are flourishing research areas and have close ties with computer science.

The Discrete Mathematics and Logic Concentration provides a firm background in discrete mathematics and mathematical logic, together with the elements of theoretical computer science. It prepares the student to pursue research in these fields, or to apply their ideas in the many disciplines (ranging from philosophy to hardware verification) where such ideas have proved relevant.

The requirements for the Discrete Mathematics and Logic Concentration are:

Mathematical Sciences and Computer Science Courses (required)

The alternative course 21-242 is particularly recommended for a student planning to pursue graduate work. Students who plan to pursue graduate study in mathematical logic are strongly advised to take 21-300.

		Units
15-122	Principles of Imperative Computation	10
15-150	Principles of Functional Programming	10
15-210	Parallel and Sequential Data Structures and Algorithms	12

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
21-300	Basic Logic	9
or 15-317	Constructive Logic	
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
21-301	Combinatorics	9
21-341	Linear Algebra	9
21-355	Principles of Real Analysis I	9
21-373	Algebraic Structures	9
		126

Computer Science electives (required)

Any two courses at the 300 level or above. The following are specifically suggested:

15-312	Foundations of Programming Languages	12
15-451	Algorithm Design and Analysis	12
15-453	Formal Languages, Automata, and Computability	9

Students pursuing this concentration who minor in Computer Science must take two additional Computer Science courses at the 300 level or above to avoid excessive double counting.

Mathematical Sciences Electives (required)

Seven courses from lists 1 and 2 below, including at least three chosen from list 1.

List 1 (Discrete Mathematics and Logic Electives)

21-325	Probability	9
21-329	Set Theory	9
21-374	Field Theory	9
21-400	Intermediate Logic	9
21-441	Number Theory	9
21-484	Graph Theory	9
21-602	Introduction to Set Theory I	12
21-603	Model Theory I	12
21-610	Algebra I	12
21-701	Discrete Mathematics	12
80-405	Game Theory	9
80-411	Proof Theory	9
80-413	Category Theory	9

List 2 (General Mathematics Electives)

21-259	Calculus in Three Dimensions	9-10
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9-10
or 21-261	Introduction to Ordinary Differential Equations	
or 33-231	Physical Analysis	
21-292	Operations Research I	9
21-356	Principles of Real Analysis II	9
21-366	Topics in Applied Mathematics	9
21-369	Numerical Methods	9
21-370	Discrete Time Finance	9
21-371	Functions of a Complex Variable	9
21-372	Partial Differential Equations and Fourier Analysis	9
21-393	Operations Research II	9
21-420	Continuous-Time Finance	9
21-470	Selected Topics in Analysis	9
21-476	Introduction to Dynamical Systems	9
21-499	Undergraduate Research Topic	9

Any graduate course in mathematics at the 600 and 700 level not included in List 1.

MCS General Education (required)

MCS or SHS humanities, social sciences, and science core (114 units)

Suggested Schedule**Freshman Year**

Fall		Units
15-112	Fundamentals of Programming and Computer Science	12
21-120	Differential and Integral Calculus	10
38-101	First-year Seminar	6
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
xx-xxx	Life/Physical Sciences Course	9
		49

Spring		Units
15-122	Principles of Imperative Computation	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
xx-xxx	Physical/Life Sciences Course	9
		49

Sophomore Year

Fall		Units
15-150	Principles of Functional Programming	10
21-268	Multidimensional Calculus	10
or 21-269	Vector Analysis	
21-301	Combinatorics	9
21-373	Algebraic Structures	9
xx-xxx	H&SS Elective	9
		47

Spring		Units
15-210	Parallel and Sequential Data Structures and Algorithms	12
xx-xxx	Discrete Math/Logic Elective	9
xx-xxx	Mathematics Elective	9
xx-xxx	STEM Course	9
xx-xxx	H&SS Elective	9
		48

Junior Year

Fall		Units
15-xxx	Computer Science Elective	9
21-300	Basic Logic	9
or 15-317	Constructive Logic	
21-355	Principles of Real Analysis I	9
xx-xxx	H&SS Elective	9
xx-xxx	STEM Course	9
		45

Spring		Units
15-xxx	Computer Science Elective	9
21-341	Linear Algebra	9
xx-xxx	H&SS Elective	9
xx-xxx	Cultural/Global Understanding Course	9
xx-xxx	Free Elective	9
		45

Senior Year

Fall		Units
xx-xxx	Discrete Math/Logic Elective	9
xx-xxx	Mathematics Elective	9
xx-xxx	Mathematics Elective	9

xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
		45

Spring		Units
xx-xxx	Discrete Math/Logic Elective	9
xx-xxx	Mathematics Elective	9
xx-xxx	Mathematics Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
		45

360 Minimum number of units required for degree:**Computational and Applied Mathematics Concentration**

This concentration is designed to prepare students for careers in business or industry which require significant analytical, computational and problem solving skills. It also prepares students with interest in computational and applied mathematics for graduate school.

The students in this concentration develop skills to choose the right framework to quantify or model a problem, analyze it, simulate and in general use appropriate techniques for carrying the effort through to an effective solution. The free electives allow the student to develop an interest in a related area by completing a minor in another department, such as Engineering Studies, Economics, Information Systems or Business Administration.

The requirements for the Computational and Applied Mathematics Concentration are:

Mathematical Sciences Courses (required)

The alternative courses 21-242, 21-261, and 21-268 (or 21-269) are particularly recommended for a student planning to pursue graduate work.

Courses		Units
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
21-228	Discrete Mathematics	9
or 15-251	Great Theoretical Ideas in Computer Science	
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
21-259	Calculus in Three Dimensions	9
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9
or 21-261	Introduction to Ordinary Differential Equations	
or 33-231	Physical Analysis	
21-320	Symbolic Programming Methods	9
36-225	Introduction to Probability Theory	9
or 21-325	Probability	
21-355	Principles of Real Analysis I	9
21-356	Principles of Real Analysis II	9
21-369	Numerical Methods	9
		112

Computer Science Courses (required)

Courses		Units
15-122	Principles of Imperative Computation	10

Mathematics Electives (required)

Students must take 36 units from the list below:

21-292	Operations Research I	9
21-341	Linear Algebra	9
21-365	Projects in Applied Mathematics	9
21-366	Topics in Applied Mathematics	9
21-370	Discrete Time Finance	9
21-371	Functions of a Complex Variable	9

21-372	Partial Differential Equations and Fourier Analysis	9
21-377	Monte Carlo Simulation for Finance	9
21-378	Mathematics of Fixed Income Markets	9
21-393	Operations Research II	9
21-420	Continuous-Time Finance	9
21-467	Differential Geometry	9
21-470	Selected Topics in Analysis	9
21-476	Introduction to Dynamical Systems	9
21-620	Real Analysis	6
21-621	Introduction to Lebesgue Integration	6
21-630	Ordinary Differential Equations	12
21-640	Introduction to Functional Analysis	12
21-651	General Topology	12
21-660	Introduction to Numerical Analysis I	12
21-690	Methods of Optimization	12
21-720	Measure and Integration	12
21-721	Probability	12
21-732	Partial Differential Equations I	12

Students must take 9 units of Mathematical Sciences (at the 21-300 level or above or 21-270 or 21-292), or Computer Science (at the 15-200 level or above), or Physics (at the 33-300 level or above), or Statistics (must have at least 36-225 as a prerequisite) electives.

21-366 Topics in Applied Mathematics and 21-470 Selected Topics in Analysis have content that varies from year to year. These courses can be taken more than once (with permission).

Note that courses 21-600 and above carry graduate credit. 600-level courses are designed as transitional courses to graduate study.

A student preparing for graduate study should also consider undertaking independent work. The Department offers 21-499 Undergraduate Research Topic and 21-599 Undergraduate Reading and Research for this purpose.

These courses can be taken as part of satisfying the Depth Elective requirement, but require permission of both the instructor and the department.

Courses 21-700 and above can be used with the permission of both the instructor and the department.

MCS General Education (required)

MCS or SHS humanities, social sciences, and science core (114 units).

Students not in MCS are required to take 15-110 Principles of Computing (10 units).

Suggested Schedule

Freshman Year

Fall		Units
21-120	Differential and Integral Calculus	10
21-126	Introduction to Mathematical Software	3
21-127	Concepts of Mathematics	10
or 21-128	Mathematical Concepts and Proofs	
38-101	First-year Seminar	6
76-101	Interpretation and Argument	9
xx-xxx	Life/Physical Sciences Course	9
		47

Spring		Units
21-122	Integration and Approximation	10
21-228	Discrete Mathematics	9
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
xx-xxx	Physical/Life Sciences Course	9
xx-xxx	H&SS Elective	9
		47

Sophomore Year

Fall		Units
15-112	Fundamentals of Programming and Computer Science	12
21-268	Multidimensional Calculus	10

or 21-269	Vector Analysis	
xx-xxx	STEM Course	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9
		49

Spring		Units
15-122	Principles of Imperative Computation	10
21-261	Introduction to Ordinary Differential Equations	10
xx-xxx	Mathematics Elective	9
xx-xxx	STEM Course	9
xx-xxx	H&SS Elective	9
		47

Junior Year

Fall		Units
21-320	Symbolic Programming Methods	9
21-325	Probability	9
21-355	Principles of Real Analysis I	9
xx-xxx	H&SS Elective	9
xx-xxx	Free Elective	9
		45

Spring		Units
21-356	Principles of Real Analysis II	9
21-369	Numerical Methods	9
xx-xxx	Depth Elective	9
xx-xxx	Cultural/Global Understanding Elective	9
xx-xxx	Free Elective	9
		45

Senior Year

Fall		Units
xx-xxx	Mathematics Elective	9
xx-xxx	Mathematics Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
		45

Spring		Units
xx-xxx	Mathematics Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
xx-xxx	Free Elective	9
		45

360Minimum units required for degree:

Double Major Requirements

All degrees offered by the Department are available as a second major to students majoring in other departments. Interested students should contact the Department for further information and guidance. In general the requirements for a second major include all the required courses except the MCS core, free electives and 21-201 Undergraduate Colloquium.

The Minor in Mathematical Sciences

The Minor includes six courses. 21-127 Concepts of Mathematics is a prerequisite for 21-228 and recommended for 21-241. The minimum preparation required for 21-355 Principles of Real Analysis I is 21-122 and 21-127 or equivalent courses.

21-127	Concepts of Mathematics	10
21-228	Discrete Mathematics	9-12
or 15-251	Great Theoretical Ideas in Computer Science	
21-241	Matrices and Linear Transformations	10
or 21-242	Matrix Theory	
21-355	Principles of Real Analysis I	9

21-3xx	Mathematical Sciences Elective
21-3xx	Mathematical Sciences Elective

To avoid excessive double counting, the two Mathematical Sciences Electives may not also count toward the student's major.

The Minor in Discrete Mathematics and Logic

This minor develops the fundamentals of discrete mathematics and logic necessary to understand the mathematical foundations of many computer related disciplines. Required courses are:

21-228	Discrete Mathematics ¹	9-12
or 15-251	Great Theoretical Ideas in Computer Science	
21-300	Basic Logic	9
or 15-317	Constructive Logic	
21-301	Combinatorics	9

¹21-127 Concepts of Mathematics is a prerequisite for 21-228.

Three of the following (at least one from each group):

Logic		
21-329	Set Theory	9
21-400	Intermediate Logic	9
21-602	Introduction to Set Theory I	12
21-603	Model Theory I	12
21-700	Mathematical Logic II	12
Algebra and Discrete Mathematics		
21-341	Linear Algebra	9
21-373	Algebraic Structures	9
21-374	Field Theory	9
21-441	Number Theory	9
21-484	Graph Theory	9
21-610	Algebra I	12
21-701	Discrete Mathematics	12

The Honors Degree Program

This demanding program leads to an M.S. in Mathematical Sciences, normally in four years, in addition to the student's B.S. degree. The key element in the program is usually the Mathematical Studies sequence. Admission to the Honors Program, in the Junior year, requires an application while admission to the Math Studies sequences is by invitation only. In the application process the Department will hold to the same high standards which apply to admission to any graduate program.

The core undergraduate honors courses are:

Freshman Year

Fall		Units
21-242	Matrix Theory (Honors version of 21-241 Matrices and Linear Transformations)	10
Spring		
21-269	Vector Analysis (Honors version of 21-268 Multidimensional Calculus)	10

Sophomore Year

Fall		
21-235	Mathematical Studies Analysis I (Honors version of 21-355 Principles of Real Analysis I)	10
21-237	Mathematical Studies Algebra I (Honors version of 21-373 Algebraic Structures)	10
Spring		
21-236	Mathematical Studies Analysis II (Honors version of 21-356 Principles of Real Analysis II)	10
21-238	Mathematical Studies Algebra II (Honors version of 21-341 Linear Algebra)	10

Honors Program Requirements:

21-901	Masters Degree Research	Var.
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Five graduate mathematics courses: 60 units

Each student in the honors degree program will have a thesis advisor in addition to his or her academic advisor. In practice, the student must start thinking about the thesis as early as possible. For this reason we include some thesis work, 3 units of 21-901 Masters Degree Research, in the Fall semester of the Senior year to allow for exploratory work under supervision. The actual thesis work is then planned for the final semester with 15 units of 21-901 Masters Degree Research. The student must give a public presentation and will be examined on the thesis and related mathematics.

The five graduate courses must include at least one course from each of the following areas:

- Analysis: for example, Measure and Integration, Complex Analysis, Functional Analysis
- Algebra, Logic, Geometry and Topology: for example, Mathematical Logic I, Algebra I, General Topology, Discrete Mathematics, Commutative Algebra, Differential Geometry
- Applied Mathematics: for example, Introduction to Continuum Mechanics, Probability Measures, Probability Theory, Graphs and Network Flows, Ordinary Differential Equations, Methods of Optimization, Introduction to Numerical Analysis I, Partial Differential Equations I, Sobolev Spaces.

Faculty

PETER B. ANDREWS, Emeritus – Ph.D., Princeton University; Carnegie Mellon, 1963–.

JEREMY AVIGAD, Professor – Ph.D., University of California, Berkeley; Carnegie Mellon, 1996–.

EGON BALAS, University Professor – Ph.D., University of Brussels; Carnegie Mellon, 1968–.

THOMAS BANCHOFF, Shelly Visiting Professor – Ph.D., University of California at Berkeley; Carnegie Mellon, 2015–.

ALBERT A. BLANK, Emeritus – Ph.D., New York University; Carnegie Mellon, 1969–.

MANUEL BLUM, University Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1999–.

THOMAS BOHMAN, Professor – Ph.D., Rutgers University; Carnegie Mellon, 1998–.

DEBORAH BRANDON, Associate Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1991–.

BORIS BUKH, Assistant Professor – Ph.D., Princeton University; Carnegie Mellon, 2012–.

CHARLES V. COFFMAN, Emeritus – Ph.D., Johns Hopkins University; Carnegie Mellon, 1962–.

CLINTON CONLEY, Assistant Professor – Ph.D., University of California Los Angeles; Carnegie Mellon, 2009–.

GERARD CORNUEJOLS, University Professor – Ph.D., Cornell University; Carnegie Mellon, 1978–.

JAMES CUMMINGS, Professor – Ph.D., Cambridge University; Carnegie Mellon, 1996–.

HASAN DEMIRKOPARAN, Associate Teaching Professor – Ph.D., Michigan State University; Carnegie Mellon, 2005–.

IRENE M. FONSECA, University Professor – Ph.D., University of Minnesota; Carnegie Mellon, 1987–.

TIMOTHY FLAHERTY, Associate Teaching Professor – Ph.D., University of Pittsburgh.; Carnegie Mellon, 1999–.

ALAN M. FRIEZE, Professor – Ph.D., University of London; Carnegie Mellon, 1987–.

IRINA GHEORGHICIUC, Assistant Teaching Professor – Ph.D., University of Pennsylvania; Carnegie Mellon, 2007–.

JAMES M. GREENBERG, Emeritus – Ph.D., Brown University; Carnegie Mellon, 1995–.

RAMI GROSSBERG, Professor – Ph.D., Hebrew University of Jerusalem; Carnegie Mellon, 1988–.

MORTON E. GURTIN, Emeritus – Ph.D., Brown University; Carnegie Mellon, 1966–.

DAVID HANDRON, Associate Teaching Professor – Ph.D., Rice University; Carnegie Mellon, 1999–.

WILLIAM J. HRUSA, Professor – Ph.D., Brown University; Carnegie Mellon, 1982–.

GAUTAM IYER, Associate Professor – Ph.D., University of Chicago; Carnegie Mellon, 2009–.

GREGORY JOHNSON, Assistant Teaching Professor – Ph.D., University of Maryland; Carnegie Mellon, 2009–.

DAVID KINDERLEHRER, Professor – Ph.D., University of California at Berkeley; Carnegie Mellon, 1990–.

DMITRY KRAMKOV, Professor – Ph.D., Steklov Mathematical Institute; Carnegie Mellon, 2000–.

KASPER LARSEN, Associate Professor – Ph.D., University of Southern Denmark; Carnegie Mellon, 2007–.

JOHN P. LEHOCZKY, Professor – Ph.D., Stanford University; Carnegie Mellon, 1969–.

GIOVANNI LEONI, Professor – Ph.D., University of Minnesota; Carnegie Mellon, 2002–.

PO-SHEN LOH, Assistant Professor – Ph.D., Princeton University; Carnegie Mellon, 2009–.

JOHN MACKEY, Teaching Professor – Ph.D., University of Hawaii; Carnegie Mellon, 2003–.

DANIELA MIHAI, Assistant Teaching Professor – Ph.D., University of Pittsburgh; Carnegie Mellon, 2007–.

RICHARD A. MOORE, Emeritus – Ph.D., Washington University; Carnegie Mellon, 1956–.

ROY A. NICOLAIDES, Professor – Ph.D., University of London; Carnegie Mellon, 1984–.

WALTER NOLL, Emeritus – Ph.D., Indiana University; Carnegie Mellon, 1956–.

MARION L. OLIVER, Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2004–.

DAVID R. OWEN, Emeritus – Ph.D., Brown University; Carnegie Mellon, 1967–.

WESLEY PEGDEN, Assistant Professor – Ph.D., Rutgers University; Carnegie Mellon, 2013–.

ROBERT L. PEGO, Professor – Ph.D., University of California at Berkeley; Carnegie Mellon, 2004–.

AGOSTON PISZTORA, Associate Professor – Ph.D., ETH Zurich; Carnegie Mellon, 1996–.

MARY RADCLIFFE, Shelly Postdoctoral Teaching Fellow – Ph.D., University of California at San Diego; Carnegie Mellon, 2015–.

SCOTT ROBERTSON, Assistant Professor – Ph.D., Boston University; Carnegie Mellon, 2011–.

HAYDEN SCHAEFFER, Assistant Professor – Ph.D., University of California at Los Angeles; Carnegie Mellon, 2015–.

JOHN W. SCHAEFFER, Professor – Ph.D., Indiana University; Carnegie Mellon, 1983–.

JUAN J. SCHÄFFER, Professor – Ph.D., Universität Zürich; Carnegie Mellon, 1968–.

ERNEST SCHIMMERLING, Professor – Ph.D., University of California at Los Angeles; Carnegie Mellon, 1998–.

DANA SCOTT, Emeritus – Ph.D., Princeton University; Carnegie Mellon, 1981–.

ROBERT F. SEKERKA, University Professor – Ph.D., Harvard University; Carnegie Mellon, 1969–.

STEVEN E. SHREVE, University Professor – Ph.D., University of Illinois; Carnegie Mellon, 1980–.

DEJAN SLEPCEV, Associate Professor – Ph.D., University of Texas at Austin; Carnegie Mellon, 2006–.

RICHARD STATMAN, Professor – Ph.D., Stanford University; Carnegie Mellon, 1984–.

SHLOMO TA'ASAN, Professor – Ph.D., Weizmann Institute; Carnegie Mellon, 1994–.

LUC TARTAR, University Professor of Mathematics Emeritus – Ph.D., University of Paris; Carnegie Mellon, 1987–.

IAN TICE, Assistant Professor – Ph.D., New York University; Carnegie Mellon, 2012–.

RUSSELL C. WALKER, Teaching Professor – D.A., Carnegie Mellon University; Carnegie Mellon, 1984–.

NOEL S. WALKINGTON, Professor – Ph.D., University of Texas at Austin; Carnegie Mellon, 1989–.

WILLIAM O. WILLIAMS, Emeritus – Ph.D., Brown University; Carnegie Mellon, 1966–.

ZELEALEM YILMA, Assistant Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2015–.

Department of Physics

Stephen Garoff, Head
Office: Wean Hall 7325
Kunal Ghosh, Assistant Head for Undergraduate Affairs
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Student Programs Office: Wean Hall 7319
<http://www.cmu.edu/physics>

Physics, one of the basic sciences, has its origin in the irrepressible human curiosity to explore and understand the natural world. This fundamental urge to discover has led to the detailed understanding of a remarkable variety of physical phenomena. Our knowledge now encompasses the large-scale movement of galaxies, the minute motions within atoms and nuclei, and the complex structure of the assemblies of molecules that make life possible. The spectacular expansion of our comprehension of the physical world forms an impressive part of the intellectual and cultural heritage of our times. The opportunity to add to this heritage is an important source of motivation for young physicists. The application of discoveries in physics to the solution of complex modern technological problems offers a vast field in which physicists make decisive contributions. The interplay of pure and applied physics has always been fruitful and today ensures many rewarding career opportunities for physics students.

Carnegie Mellon's undergraduate curriculum in physics has been carefully designed to provide a firm knowledge of the basic principles of physics, an appreciation of a wide range of physical problems of current interest, and the capacity to formulate and solve new problems. In addition to classwork and problem solving, the curriculum includes studying physical phenomena in the laboratory. Physics students are strongly encouraged to go beyond the formal theoretical and experimental course work and become involved in research projects under the guidance of individual faculty members.

Students may choose from a variety of degree options:

- B.S. in Physics
- B.A. in Physics
- B.S. in Physics with Tracks in:
 - Applied Physics
 - Astrophysics
 - Biological Physics
 - Chemical Physics
 - Computational Physics

The objectives and requirements for each of these options are described in the paragraphs below. Each allows considerable latitude in the choice of electives.

Through the judicious choice of elective courses, a double major program combining physics and another discipline can be readily achieved. A minor in physics is also offered for those students who major in other disciplines. The student, with the help of their faculty advisors, can easily build a program that aims at specific career objectives.

The Department maintains an active and wide-ranging program of advising. Beyond aiding in academic planning, the department advisors can also assist students in finding research work during the academic year, technical jobs and internships for the summer, as well as planning and executing the necessary steps for gaining employment or continuing their studies beyond the bachelor's degree. Whether students follow a standard curriculum or not, they should consult their academic advisor at least once every semester.

B.S. in Physics

B.S. degree candidates can choose studies in not only a wide variety of intermediate and advanced topics in physics but also a range of material in other science or engineering fields. The B.S. degree provides a solid foundation for students wishing to go on to graduate work in physics or any of a large number of fields in pure or applied science or engineering, for which a sound grasp of physics and mathematics is essential. This program also provides excellent preparation for careers in teaching, for work in industrial or governmental research and development, or for other employment in business or industry with a significant scientific component.

Degree Requirements are as follows:

- Carnegie Mellon University Requirements
 - A minimum of 360 units is required.

- 99-101, 99-102, or 99-103 Computing @ Carnegie Mellon

- [MCS Technical Breadth Requirements](#)
See MCS section of this catalog
- [MCS Nontechnical Breadth Requirements](#)
See MCS Section of this catalog
- Additional Core Physics/Math Courses
 - 33-104 Experimental Physics
 - 33-211 Physics III: Modern Essentials
 - 33-228 Electronics I
 - 33-231 Physical Analysis
 - 33-232 Mathematical Methods of Physics
 - 33-234 Quantum Physics
 - 33-331 Physical Mechanics I
 - 33-338 Intermediate Electricity and Magnetism I
 - 33-340 Modern Physics Laboratory
 - 33-341 Thermal Physics I
 - 21-259 Calculus in Three Dimensions
- Physics Colloquium Courses
 - 33-201 Physics Sophomore Colloquium I
 - 33-202 Physics Sophomore Colloquium II
 - 33-301 Physics Upperclass Colloquium I
 - 33-302 Physics Upperclass Colloquium II
- Physics, Mathematics and Technical Electives
 - 8 courses of at least 9 units each
 - Allowed courses depend on track chosen: see below.
- Free Electives
 - Approximately 26 units: actual number depends on track chosen and satisfying 360 total units
 - A free elective is any Carnegie Mellon course; however, a maximum of 9 units of physical education and/or military science and/or StuCo courses may be taken as free electives.

We offer a Physics Major with or without a track. A track is like a "menu deal" at a fast-food restaurant: when one chooses a track, one gets a package of physics and other required courses and electives. The specialized electives for each of the tracks are described below:

- No Track (p. 349)
- Applied Physics (p. 349)
- Astrophysics (p. 349)
- Biological Physics (p. 350)
- Chemical Physics (p. 350)
- Computational Physics (p. 350)

A student does not need to choose a track but can follow the general, non-track physics curriculum. You can also take all the courses that a track requires without being in a track. You can declare, change, or leave your track by discussing with the Assistant Head for Undergraduate Affairs.

Students planning to undertake graduate studies in physics are strongly advised to take the following courses:

- 33-332 Physical Mechanics II
- 33-339 Intermediate Electricity and Magnetism II
- 33-445 Adv Quantum Physics I
- 33-446 Advanced Quantum Physics II

Qualifying Electives in Physics

The following courses qualify as specialized Physics Electives for the B.S. and B.A. degrees and the Minor of Physics:

- 33-114 Physics of Musical Sound (B.A. and minor only)
- 33-120 Science and Science Fiction (B.A. and minor only)
- 33-224 Stars, Galaxies and the Universe (Fall)
- 33-241 Introduction to Computational Physics (Fall)
- 33-332 Physical Mechanics II (Spring)
- 33-339 Intermediate Electricity and Magnetism II (Spring)

- 33-342 Thermal Physics II (Spring)
- 33-350 Undergraduate Research
- 33-353 Intermediate Optics (Alt. Fall - F16, F18)
- 33-355 Nanoscience and Nanotechnology (Alt. Fall - F15, F17)
- 33-398 Special Topics
- 33-441 Introduction to BioPhysics (Fall)
- 33-444 Introduction to Nuclear and Particle Physics (Spring)
- 33-445 Adv Quantum Physics I (Fall)
- 33-446 Advanced Quantum Physics II (Spring)
- 33-448 Introduction to Solid State Physics (Spring)
- 33-451 Senior Research
- 33-456 Advanced Computational Physics (Spring)
- 33-466 Extragalactic Astrophysics and Cosmology (Spring)
- 33-467 Astrophysics of Stars and the Galaxy (Fall)
- 33-499 Supervised Reading
- 33-650 General Relativity (Fall)
- 33-658 Quantum Computation and Quantum Information Theory (Alt. Spring - S16, S18)
- 33-7xx Physics Graduate Level Courses (see list below)

Only one of the two courses - 33-114 and 33-120 may be used for BA.

Only one of the two courses - 33-350 (at least 9 units), 33-451 (at least 9 units), and 33-499 (at least 9 units) - may be used to satisfy as a Qualifying Elective in Physics. Any exceptions must be pre-approved by the Assistant Head for Undergraduate Affairs.

Physics Breadth Electives

A Physics Major with or without a track, one of the Physics electives must be a Physics "breadth" Elective course to be chosen from the following:

- 33-353 Intermediate Optics (Alt. Fall- F16, F18)
- 33-355 Nanoscience and Nanotechnology (Alt. Fall- F15, F17)
- 33-441 Introduction to BioPhysics (Fall)
- 33-444 Introduction to Nuclear and Particle Physics (Spring)
- 33-448 Introduction to Solid State Physics (Spring)
- 33-466 Extragalactic Astrophysics and Cosmology (Spring)
- 33-467 Astrophysics of Stars and the Galaxy (Fall)
- 33-650 General Relativity (Fall)
- 33-658 Quantum Computation and Quantum Information Theory (Alt. Spring- S16, S18)

Some of these courses are included in particular tracks. Then, no additional Physics Breadth Elective need to be chosen.

Physics Graduate Courses

- 33-755 Quantum Mechanics I
- 33-756 Quantum Mechanics II
- 33-758 Quantum Computation and Quantum Information Theory
- 33-759 Introduction to Mathematical Physics I
- 33-761 Classical Electrodynamics I
- 33-762 Classical Electrodynamics II
- 33-765 Statistical Mechanics
- 33-767 Biophysics: From Basic Concepts to Current Research
- 33-769 Quantum Mechanics III: Many Body and Relativistic Systems
- 33-770 Field Theory I
- 33-771 Field Theory II
- 33-777 Introductory Astrophysics
- 33-779 Introduction to Nuclear and Particle Physics
- 33-780 Nuclear and Particle Physics II
- 33-783 Solid State Physics

B.S. in Physics - Sample Schedule (No Track) BEGINNING FALL 2015 AND BEYOND

(For the previous catalog, visit cmu.edu/physics)

First Year

Fall		Units
38-101	EUREKA!: Discovery and Its Impact	6
21-xxx	Calculus Course	10

33-111	Physics I for Science Students	12
or 33-151	Matter and Interactions I	
xx-xxx	MCS/Physics Technical Breadth Requirement 1*	9-12
76-101	Interpretation and Argument	9
or xx-xxx	MCS Nontechnical Breadth Requirement**	9
99-10x	Computing@Carnegie Mellon	3
xx-xxx	Optional 6 Unit Course	6

Max units is 54 (57 units if C@CM is completed over the summer)

Spring		
33-142	Physics II for Engineering and Physics Students	12
or 33-152	Matter and Interactions II	
33-104	Experimental Physics	9
21-122	Integration and Approximation	10
38-110	ENGAGE in Service	1
xx-xxx	MCS Cultural/Global Understanding Category***	9
XX-XXX	MCS/Physics Technical Breadth Requirement 2*	9-12

Sophomore Year

Fall		
33-211	Physics III: Modern Essentials	10
33-231	Physical Analysis	10
33-201	Physics Sophomore Colloquium I	2
21-259	Calculus in Three Dimensions	9
38-220	ENGAGE in the Arts	2
xx-xxx	MCS/Physics Technical Breadth Requirement 3*	9-12
xx-xxx	MCS Nontechnical Breadth Requirement*	9

Spring

33-232	Mathematical Methods of Physics	10
33-228	Electronics I	10
33-234	Quantum Physics	10
33-202	Physics Sophomore Colloquium II	2
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	MCS/Physics Technical Breadth Requirement 4*	9-12

Junior Year

Fall		
33-331	Physical Mechanics I	10
33-338	Intermediate Electricity and Magnetism I	10
33-341	Thermal Physics I	10
33-301	Physics Upperclass Colloquium I	1
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Physics, Technical, or Free Elective (1 of 10)	9

Spring

33-340	Modern Physics Laboratory	10
33-302	Physics Upperclass Colloquium II	1
xx-xxx	Physics, Technical or Free Elective (2 of 10)	9
xx-xxx	Physics, Technical or Free Elective (3 of 10)	9
xx-xxx	Physics, Technical or Free Elective (4 of 10)	9
38-301	MCS Junior Seminar	6

Senior Year

Fall		
21-xxx	Mathematics Elective	9
xx-xxx	Physics, Technical or Free Elective (5 of 10)	9
xx-xxx	Physics, Technical or Free Elective (6 of 10)	9
xx-xxx	Physics, Technical or Free Elective (7 of 10)	9
38-430	ENGAGE in Wellness: Looking Forward	1
xx-xxx	MCS Core Science Requirement	9

Spring

xx-xxx	Physics, Technical or Free Elective (8 of 10)	9
xx-xxx	Physics, Technical or Free Elective (9 of 10)	9
xx-xxx	Physics, Technical or Free Elective (10 of 10)	9
xx-xxx	Dietrich College/FA Course (MCS Core 8 of 8)	9

* MCS/Physics Technical Breadth Requirement Category- Life Sciences: 03-121; Physical Sciences 09-105; Mathematics, Statistics, and Computer Science: 15-110 or 15-112.

**MCS Nontechnical Breadth Requirement Category; see MCS Catalog

***MCS Cultural Global Understanding Category; see MCS Catalog

B.A. in Physics

The Bachelor of Arts degree in Physics offers a flexible program that allows students to combine the study of Physics with the opportunity to do intensive work in substantive areas such as liberal arts, teaching, business or law. With 82 units of free electives, it is feasible for students to obtain, for example, a double major with a department in the College of Humanities and Social Sciences, the College of Fine Arts, or the Tepper School of Business. It is expected that students will focus their elective courses in a well defined academic area. Students must meet with the Assistant Head for undergraduate Affairs and construct an approved plan of study.

The requirements for the B.A. degree are the same as for the B.S. degree, except that the 8 Physics, Mathematics and Technical Electives in the B.S. program become Free Electives in the BA program.

Degree Requirements are as follows:

- Carnegie Mellon University Requirements
 - A minimum of 360 units is required.
 - 99-101, 99-102, or 99-103 Computing @ Carnegie Mellon
- MCS Technical Breadth Requirements
See MCS section of this catalog
- MCS Nontechnical Breadth Requirements
See MCS section of this catalog

In addition, all core MCS requirements are listed in the MCS sections of this catalog, and must be fulfilled on time.

- Additional Core Physics/Math Courses
 - 33-104 Experimental Physics (by fall of sophomore year)
 - 33-211 Physics III: Modern Essentials
 - 33-228 Electronics I
 - 33-231 Physical Analysis
 - 33-232 Mathematical Methods of Physics
 - 33-234 Quantum Physics
 - 33-331 Physical Mechanics I
 - 33-338 Intermediate Electricity and Magnetism I
 - 33-341 Thermal Physics I
 - 21-259 Calculus in Three Dimensions
- Physics Colloquium Courses
 - 33-201 Physics Sophomore Colloquium I
 - 33-202 Physics Sophomore Colloquium II
 - 33-301 Physics Upperclass Colloquium I
 - 33-302 Physics Upperclass Colloquium II
- Qualifying Physics Electives (p. 347)
 - 2 courses of at least 9 units each
- Free Electives
 - Approximately 82 units: actual number depends on satisfying 360 total units
 - A free elective is any Carnegie Mellon course; however, a maximum of 9 units of physical education and/or military science and/or StuCo courses may be taken as free electives.

Physics Breadth Electives for Different Tracks

A Physics Major with or without a track, one of the Physics electives must be a Physics "breadth" Elective course to be chosen from the following:

- 33-353 Intermediate Optics (Alt. Fall- F16, F18)
- 33-355 Nanoscience and Nanotechnology (Alt. Fall- F15, F17)
- 33-441 Introduction to BioPhysics (Fall)
- 33-444 Introduction to Nuclear and Particle Physics (Spring)
- 33-448 Introduction to Solid State Physics (Spring)
- 33-466 Extragalactic Astrophysics and Cosmology (Spring)
- 33-467 Astrophysics of Stars and the Galaxy (Fall)
- 33-650 General Relativity (Fall)

- 33-658 Quantum Computation and Quantum Information Theory (Alt. Spring- S16, S18)

Some of these courses are included in particular tracks. Then, no additional Physics Breadth Elective need to be chosen.

B.S. in Physics / No Track

The 8 Physics, Mathematics and Technical courses for the B.S. in the Physics without a track are as follows:

- Physics Electives
 - 4 courses of at least 9 unit each
 - must be chosen from the Qualifying Physics Electives (p. 347), at least one of which must be chosen from Physics Breadth Electives (p. 348)
- Math Elective
 - 1 course of at least 9 units
 - chosen from any 21-2xx or higher level courses except 21-350
- Technical Electives
 - 3 courses of at least 9 units each
 - Technical electives are any courses in MCS, SCS, Statistics, CIT, and others explicitly approved by the Assistant Head for Undergraduate Affairs.

B.S. in Physics / Applied Physics Track

The B.S. in Physics/Applied Physics Track is designed primarily for the student who wants to prepare for a career path that takes advantage of the diverse and expanding opportunities for employment in industrial and government laboratories with a B.S. degree. The program provides a solid foundation in the concepts of physics, as well as giving the student the experience and understanding of the application of these concepts. The track is intended to enhance computing and laboratory skills, and to introduce the application of physics to those subjects of particular interest to the student. Since the possible subject areas for study are so varied, the track will be tailored to each student's needs within the framework described below.

The 8 Physics, Mathematics and Technical courses for the B.S. in the Applied Physics Track are as follows:

- Physics/Technical Courses
 - 33-448 Introduction to Solid State Physics
 - One course (at least 9 units) which strengthens the student's ability to use the computer as a tool in the research environment
 - Two courses (at least 18 units), at least one of them in another department, which broaden the student's laboratory skills
 - Two courses (at least 18 units), at least one of them in another department, which give the student experience in applying basic physics principles to a variety of problems
 - One research course: either 33-350 or 33-451
 - the research topic must be applied physics related and must be approved by the Assistant Head for Undergraduate Affairs.
- Math Elective
 - One course of at least 9 units
 - chosen from any 21-2xx or higher level course except 21-350.

Details of what may constitute the elective courses in the Physics/Technical Courses Requirement are decided after consultation with, and approved by, the Assistant Head for Undergraduate Affairs.

B.S. in Physics / Astrophysics Track

The B.S. in Physics/Astrophysics Track provides an option for those Physics majors who either want to specialize in this subfield or plan careers in astronomy or astrophysics. Career paths may include postgraduate training in astronomy or astrophysics or proceeding directly to jobs in these fields. The program provides a thorough foundation in the core physics program with electives concentrating in astrophysics.

The 8 Physics, Mathematics and Technical courses for the B.S. in the Astrophysics Track are as follows:

- Astrophysics Courses
 - 33-224 Stars, Galaxies and the Universe
 - 33-466 Extragalactic Astrophysics and Cosmology
 - 33-467 Astrophysics of Stars and the Galaxy
 - 1 research course: either 33-350 or 33-451

- the research topic must be astrophysics related and must be approved by the Assistant Head for Undergraduate Affairs.
- Math Elective
 - 1 course of at least 9 units
 - chosen from any 21-2xx or higher level course except 21-350
- Technical Electives
 - 3 courses of 9 units each
 - Technical electives are any courses in MCS, SCS, Statistics, CIT, and others explicitly approved by the Physics Department.

B.S. in Physics / Biological Physics Track

The B.S. in Physics/Biological Physics Track combines a rigorous foundation in undergraduate physics with courses in Biological Physics and Chemistry. It is particularly suitable for students preparing for post-baccalaureate careers in the expanding areas of biological and medical physics or for graduate study in biophysics. The program is sufficiently flexible that it can be readily adapt to the requirements of individual students. The student will first meet with the Assistant Head for Undergraduate Affairs to discuss interests and career goals and then choose electives which fulfill the requirements of the track.

The Biological Physics Track includes a number of courses which are also requirements for the pre-medical program. Students interested in both the Biological Physics Track and the pre-medical program should consult with both the Assistant Head for Undergraduate Affairs in the Physics Department and the Director of the Health Professions Program for help in planning their programs.

The 8 Physics, Mathematics and Technical courses for the B.S. in the Biological Physics Track are as follows:

- Physics Courses
 - 33-441/03-439 Introduction to Biophysics
 - One course of at least 9 units
 - must be chosen from the Qualifying Physics Electives (p. 347)
- Math Elective
 - One course of at least 9 units
 - chosen from any 21-2xx or higher level course except 21-350.
- Biological Sciences/Chemistry Courses
 - 03-231 Biochemistry I
 - 09-217 Organic Chemistry I
 - 09-218 Organic Chemistry II
 - 2 courses (18 units) in Biological Sciences

Details of what may constitute the elective courses in Biological Sciences are decided after consultation with, and approved by, the Assistant Head for Undergraduate Affairs.

B.S. in Physics / Chemical Physics Track

The B.S. in Physics/Chemical Physics Track is designed for students wishing to have a strong grounding in physics along with a specialization in physical chemistry and/or chemical physics. It is particularly suitable for those students planning on graduate studies in physics with an emphasis on chemical physics or chemistry. The program is sufficiently flexible that it can be readily adapted to the requirements of individual students. The student will first meet with the Assistant Head for Undergraduate Affairs to discuss interests and career goals and then choose electives that fulfill the requirements of the track.

The Chemical Physics Track incorporates a number of courses which are also requirements for the pre-medical program. Students interested in both the Chemical Physics Track and the pre-medical program should consult both with their Physics Department advisor and the Director of the Health Professions Program for help in planning their programs.

The 8 Physics, Mathematics and Technical courses for the B.S. in the Chemical Physics Track are as follows:

- Physics Course
 - One course of at least 9 units
 - must be chosen from the Physics Breadth Electives for Different Tracks. (p. 347)

- Math Elective
 - One course of at least 9 units
 - chosen from any 21-2xx or higher level course except 21-350.
- Chemistry Courses
 - 09-106 Modern Chemistry II
 - 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry
 - 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry
 - 3 courses (27 units) in Chemistry

Details of what may constitute the elective courses in Chemistry are decided after consultation with, and approved by, the Assistant Head for Undergraduate Affairs.

B.S. in Physics / Computational Physics Track

The B.S. in Physics/Computational Physics Track is intended to fill the increasing demand for physics graduates who are skilled in computational and numerical techniques which are used in the analysis of physical problems and in subjects ranging from control and real-time programming to software engineering and compiler and operating systems design. The degree provides the student with a rigorous grounding in physics as well as in the foundations and practice of computer use as applied to scientific problems. Work is done on machines ranging from high level workstations through supercomputers.

The track program includes additional courses from the Mathematics and Computer Science Departments as well as special courses in computational physics from the Physics Department. The program is sufficiently flexible that it can be readily adapted to the requirements of individual students. The student will first meet with the Assistant Head for Undergraduate Affairs to discuss interests and career goals and then choose electives that fulfill the requirements of the track.

The 8 Physics, Mathematics and Technical courses for the B.S. in the Computational Physics Track are as follows:

- Physics Courses
 - 33-241 Introduction to Computational Physics
 - 33-456 Advanced Computational Physics
 - Two courses of at least 9 units each
 - Must be chosen from the Qualifying Physics Electives (p. 347), at least one of which must be chosen from Physics Breadth Electives for Different Tracks (p. 349).
- Mathematics and Computer Science Courses
 - 21-127 Concepts of Mathematics
 - 21-369 Numerical Methods
 - 15-122 and 15-150
 - However, the student must check with the Assistant Head for Undergraduate Affairs for the latest required Computer Science courses for this track.

Double Major or a Dual Degree in Physics with a Degree in another Department

Physics may be taken as a second major or for a second degree, with another department granting the primary degree. The rules of the Physics Department for these two options are distinct, as discussed below.

Double Major

In order to receive a Double Major in Physics, with another department granting the primary degree — with a B.S. or B.A., alone or with any track — all requirements of the Physics degree and the particular physics track, as listed in the previous sections, must be fulfilled except:

- No units of Technical Electives are required
- No units of Free Electives are required
- No H&SS/FA courses are required
- The following courses in the MCS core are not required: 03-121 Modern Biology, 09-105 Introduction to Modern Chemistry I

- However, 15-110 Principles of Computing or 15-112 Fundamentals of Programming and Computer Science (or equivalent as pre-approved by the Associate Dean of Mellon College of Science) is still required.

Dual Degree

In order to receive a Dual Degree in another subject and Physics, with another department granting the primary degree — with a B.S. or B.A. alone or with any track — all requirements of the Physics degree and the particular physics track, as listed in the previous sections, must be fulfilled. The non-technical requirement is as per the Mellon College of Science; however, any course used for another department's or college's core requirement may be double counted for this purpose. The number of units required is 90 more than the total units required by the department requiring the fewer total units.

Minor in Physics

The Minor in Physics is designed to provide a solid foundation in physics at the introductory level, followed by elective courses which will familiarize the student with areas of modern physics, and the concepts and techniques employed therein. The Physics minor requires seven courses of at least 9 units each, of which four are required and three are electives.

- **Required Courses**
 - Introductory Physics I (one of 33-106, 33-111, 33-131)
 - Introductory Physics II (one of 33-107, 33-112, 33-132)
 - Physics III: Modern Essentials (33-211)
 - Experimental Physics (33-104)
- **Electives**
 - 3 physics electives, chosen from the Qualifying Physics Electives (<https://coursecatalog-new.web.cmu.edu/melloncollegeofscience/departmentofphysics/#qualifyingelectivesinphysics>)list
 - choice requires prior approval by the Assistant Head for Undergraduate Affairs

The minor is open to all students of the university, although students with non-calculus based majors should be aware of the mathematics requirements for many physics courses (21-120, 21-122, 21-259).

Faculty

DAVID ANDERSON, Assistant Professor of Physics – Ph.D., University of York (UK) ; Carnegie Mellon, 2008–.

ROY A. BRIERE, Professor of Physics – Ph.D., University of Chicago; Carnegie Mellon, 1999–.

RUPERT CROFT, Professor of Physics – Ph.D., Oxford University; Carnegie Mellon, 2001–.

MARKUS DESERNO, Associate Professor of Physics – Ph. D., University of Mainz, Germany; Carnegie Mellon, 2007–.

TIZIANA DI MATTEO, Professor of Physics – Ph.D., University of Cambridge; Carnegie Mellon, 2004–.

ALEX EVILEVITCH, Associate Professor of Physics – Ph.D., Lund University, Sweden; Carnegie Mellon, 2009–.

RANDALL M. FEENSTRA, Professor of Physics – Ph.D., California Institute of Technology; Carnegie Mellon, 1995–.

THOMAS A. FERGUSON, Professor of Physics – Ph.D., University of California at Los Angeles; Carnegie Mellon, 1985–.

GREGG B. FRANKLIN, Professor of Physics – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1984–.

STEPHEN GAROFF, Professor of Physics; Head, Department of Physics – Ph.D., Harvard University; Carnegie Mellon, 1988–.

KUNAL GHOSH, Teaching Professor of Physics, Assistant Head for Undergraduate Affairs, Department of Physics – Ph.D., Iowa State University; Carnegie Mellon, 2001–.

FREDERICK J. GILMAN, Buhl Professor of Physics; Dean, Mellon College of Science – Ph.D., Princeton University; Carnegie Mellon, 1995–.

SHIRLEY HO, Cooper-Siegel Career Development Assistant Professor of Physics – Ph.D., Princeton University; Carnegie Mellon, 2012–.

RICHARD F. HOLMAN, Professor of Physics – Ph.D., Johns Hopkins University; Carnegie Mellon, 1987–.

BENJAMIN HUNT, Assistant Professor of Physics – Ph.D., Cornell University; Carnegie Mellon, 2009–.

GEORGE KLEIN, Associate Teaching Professor of Physics – Ph.D., New York University; Carnegie Mellon, 1993–.

MICHAEL J. LEVINE, Professor of Physics, Director of Pittsburgh Supercomputer Center – Ph.D., California Institute of Technology; Carnegie Mellon, 1968–.

MATHIAS LOSCHE, Professor of Physics – Ph.D., Technical University of Munich; Carnegie Mellon, 2005–.

BARRY B. LUOKKALA, Teaching Professor of Physics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1980–.

SARA A. MAJETICH, Professor of Physics – Ph.D., University of Georgia; Carnegie Mellon, 1990–.

RACHEL MANDELBAUM, Falco-DeBenedetti Career Development Associate Professor in Physics – Ph.D., Princeton University; Carnegie Mellon, 2012–.

CURTIS A. MEYER, Professor of Physics; Associate Dean, Mellon College of Science; – Ph.D., University of California, Berkeley; Carnegie Mellon, 1993–.

COLIN J. MORNINGSTAR, Professor of Physics – Ph.D., University of Toronto; Carnegie Mellon, 2000–.

MANFRED PAULINI, Professor of Physics – Ph.D., University of Erlangen, Germany; Carnegie Mellon, 2000–.

JEFFREY B. PETERSON, Professor of Physics – Ph.D., University of California, Berkeley; Carnegie Mellon, 1993–.

BRIAN P. QUINN, Professor of Physics – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1988–.

IRA Z. ROTHSTEIN, Professor of Physics – Ph.D., University of Maryland at College Park; Carnegie Mellon, 1997–.

JAMES S. RUSS, Professor of Physics – Ph.D., Princeton University; Carnegie Mellon, 1967–.

REINHARD A. SCHUMACHER, Professor of Physics – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1987–.

ROBERT M. SUTER, Professor of Physics – Ph.D., Clark University; Carnegie Mellon, 1981–.

ROBERT H. SWENDSEN, Professor of Physics – Ph.D., University of Pennsylvania; Carnegie Mellon, 1984–.

HY TRAC, Assistant Professor of Physics – Ph.D., University of Toronto; Carnegie Mellon, 2010–.

HELMUT VOGEL, Professor of Physics – Ph.D., University of Erlangen-Nuremberg; Carnegie Mellon, 1983–.

MATTHEW WALKER, Assistant Professor of Physics – Ph.D., University of Michigan; Carnegie Mellon, 2013–.

MICHAEL WIDOM, Professor of Physics – Ph.D., University of Chicago; Carnegie Mellon, 1985–.

DI XIAO, Assistant Professor of Physics – Ph.D., University of Texas, Austin; Carnegie Mellon, 2012–.

Emeriti Faculty

LUC BERGER, Professor of Physics, Emeritus – Ph.D., University of Lausanne, Switzerland; Carnegie Mellon, 1960–.

RICHARD M. EDELSTEIN, Professor of Physics, Emeritus – Ph.D., Columbia University; Carnegie Mellon, 1960–.

ARNOLD ENGLER, Professor of Physics, Emeritus – Ph.D., University of Berne, Switzerland; Carnegie Mellon, 1962–.

JOHN G. FETKOVICH, Professor of Physics, Emeritus – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1959–.

RICHARD GRIFFITHS, Professor of Physics, Emeritus – Ph.D., University of Leicester, U.K.; Carnegie Mellon, 1996–.

ROBERT GRIFFITHS, University Professor of Physics, Emeritus – Ph.D., Stanford University; Carnegie Mellon, 1962–.

LEONARD S. KISSLINGER, Professor of Physics, Emeritus – Ph.D., Indiana University; Carnegie Mellon, 1969–.

ROBERT W. KRAEMER, Professor of Physics, Emeritus – Ph.D., Johns Hopkins University; Carnegie Mellon, 1965–.

LING-FONG LI, Professor of Physics, Emeritus – Ph.D., University of Pennsylvania; Carnegie Mellon, 1974–.

JOHN F. NAGLE, Professor of Physics, Emeritus – Ph.D., Yale University; Carnegie Mellon, 1967–.

JOHN A. RAYNE, Professor of Physics, Emeritus – Ph.D., University of Chicago; Carnegie Mellon, 1963–.

ROBERT T. SCHUMACHER, Professor of Physics, Emeritus – Ph.D., University of Illinois; Carnegie Mellon, 1957–.

ROBERT F. SEKERKA, University Professor of Physics and Mathematics, Emeritus – Ph.D., Harvard ; Carnegie Mellon, 1969–.

NED S. VANDER VEN, Professor of Physics, Emeritus – Ph.D., Princeton University; Carnegie Mellon, 1961–.

Joint Appointments and Courtesy Appointments

SHELLEY ANNA, Professor of Mechanical and Chemical Engineering – Ph.D., Harvard University; Carnegie Mellon, 2003–.

DAVID GREVE, Professor of Electrical & Computer Engineering – Ph.D., Lehigh University; Carnegie Mellon, 1982–.

MOHAMMAD F. ISLAM, Associate Research Professor of Materials Science & Engineering – Ph.D., University of Pennsylvania; Carnegie Mellon, 2005–.

MICHAEL E. MCHENRY, Professor of Materials Science and Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1989–.

ANTHONY D. ROLLETT, Professor of Materials Science & Engineering – Ph.D., Drexel University; Carnegie Mellon, 1995–.

JIAN-GANG ZHU, Professor of Electrical and Computer Engineering – Ph.D., University of California San Diego; Carnegie Mellon, 1997–.

School of Computer Science

Andrew Moore, Dean
 Klaus Sutner, Associate Dean for Undergraduate Education
 Thomas Cortina, Assistant Dean for Undergraduate Education
 Undergraduate Office: GHC 4115
<https://www.csd.cs.cmu.edu/academics/undergraduate/overview>

Carnegie Mellon founded one of the first Computer Science departments in the world in 1965. Today, the Computer Science Department forms the centerpiece of the School of Computer Science, and is joined by the Human-Computer Interaction Institute, the Institute for Software Research, the Computational Biology Department, the Language Technologies Institute, the Machine Learning Department, and the Robotics Institute. Together, these units make the School of Computer Science a world leader in research and education.

The B.S. program in Computer Science combines a solid core of Computer Science courses with the ability to gain substantial depth in another area through a required minor in a second subject. In addition, the curriculum provides numerous choices for science, engineering, humanities and fine arts courses. As computing is a discipline with strong links to many fields, this provides students with unparalleled flexibility to pursue allied (or non-allied) interests. The curriculum's mathematics and probability component ensures that students have the formal tools to remain current as technologies and systems change, rather than be limited by a narrow focus on programming alone. At the same time, students gain insight into the practical issues of building and maintaining systems by participating in intensive project-oriented courses. Due to the tremendous number of ongoing research projects within the School, many students obtain part-time or summer jobs, or receive independent study credit, working on research while pursuing their undergraduate degree. Students seeking a research/graduate school career may pursue an intensive course of research, equivalent to four classroom courses, culminating in the preparation of a senior research thesis.

Students apply to, and are directly admitted into, the undergraduate program in Computer Science and, upon successful completion, are awarded a Bachelor of Science in Computer Science. Suitably prepared students from other Carnegie Mellon colleges are eligible to apply for internal transfer to the School of Computer Science and will be considered for transfer if grades in core CS requirements are sufficiently high and space is available. Computation-oriented programs are also available within the Departments of Biology, Chemistry, Physics, Electrical and Computer Engineering, Information Systems, Philosophy, Psychology, and Design. We also offer a B.S. degree in Computational Biology, a B.S. degree in Statistics and Machine Learning (jointly with the Dietrich College of Humanities and Social Sciences) and a Bachelor's Degree in Computer Science and the Arts (jointly with the College of Fine Arts). SCS offers additional majors in Computer Science (for non-CS majors), Human-Computer Interaction, and Robotics, and minors in Computational Biology, Computer Science (for non-CS majors), Human-Computer Interaction, Language Technologies, Machine Learning, Neural Computation, Robotics, and Software Engineering.

Curriculum - B.S. in Computer Science

Computer Science

Computer Science Core (all of the following):		Units
15-128	Freshman Immigration Course	1
15-122	Principles of Imperative Computation (students with no prior programming experience take 15-112 before 15-122)	10
15-150	Principles of Functional Programming	10
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-213	Introduction to Computer Systems	12
15-251	Great Theoretical Ideas in Computer Science	12
15-451	Algorithm Design and Analysis	12
One Communications course:		Units
15-221	Technical Communication for Computer Scientists	9
15-300	Research and Innovation in Computer Science	9
76-270	Writing for the Professions	9

One Algorithms/Complexity elective (min. 9 units):

15-354	Computational Discrete Mathematics	12
15-355	Modern Computer Algebra	9
15-453	Formal Languages, Automata, and Computability	9
15-455	Undergraduate Complexity Theory	9
15-456	Computational Geometry	9
21-301	Combinatorics	9
21-484	Graph Theory	9

others as designated by the CS Undergraduate Program

One Logics/Languages elective (min. 9 units):

15-312	Foundations of Programming Languages	12
15-317	Constructive Logic	9
15-414	Bug Catching: Automated Program Verification and Testing	9
15-424	Foundations of Cyber-Physical Systems	12
21-300	Basic Logic	9
80-310	Formal Logic	9
80-311	Undecidability and Incompleteness	9

others as designated by the CS Undergraduate Program

One Software Systems elective (min. 12 units):

15-410	Operating System Design and Implementation	15
15-411	Compiler Design	15
15-418	Parallel Computer Architecture and Programming	12
15-440	Distributed Systems	12
15-441	Computer Networks	12

others as designated by the CS Undergraduate Program

One Applications elective, representing important branches of computer science (min. 9 units):

02-510	Computational Genomics	12
05-391	Designing Human Centered Software	12
10-401	Introduction to Machine Learning (or 10-601 Introduction to Machine Learning)	12
11-411	Natural Language Processing	12
15-313	Foundations of Software Engineering	12
15-322	Introduction to Computer Music (or 15-323 Computer Music Systems and Information Processing)	9
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-415	Database Applications	12
15-462	Computer Graphics	12
16-384	Robot Kinematics and Dynamics	12
16-385	Computer Vision	9

others as designated by the CS Undergraduate Program

Two Computer Science electives:

Units

18
 These electives can be from any SCS department; 200-level or above, at least 9 units each (see exceptions below): Computer Science [15-], Computational Biology Department [02-], Human Computer Interaction Institute [05-], Institute for Software Research [08-,17-], Machine Learning [10-], Language Technologies Institute [11-], and Robotics Institute [16-]. (NOTE: The following courses do NOT count as Computer Science electives: 02-201, 02-223, 02-250, 02-261, 08-200, 15-351, 16-223. Consult with a CS undergraduate advisor before registration to determine eligibility for this requirement.)

Mathematics

All of the following three courses:

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10

One of the following Matrix Algebra courses:

21-241	Matrices and Linear Transformations	10
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21-242	Matrix Theory	10
One of the following Probability courses:		
15-359	Probability and Computing	12
21-325	Probability	9
36-217	Probability Theory and Random Processes	9
36-225	Introduction to Probability Theory	9

Science and Engineering

Four courses in science and engineering are required, of which at least one must have a laboratory component and at least two must be from the same department. At present, courses meeting the lab requirement are:

02-261	Quantitative Cell and Molecular Biology Laboratory	9
03-124	Modern Biology Laboratory	9
09-101	Introduction to Experimental Chemistry (This 3 unit lab together with 09-105 satisfies the lab requirement.)	3
09-221	Laboratory I: Introduction to Chemical Analysis	12
27-100	Engineering the Materials of the Future	12
33-104	Experimental Physics	9
42-203	Biomedical Engineering Laboratory	9
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9

The following courses from the Dietrich College of Humanities and Social Sciences and University Wide Studies can be used to satisfy the Science and Engineering requirement:

85-219	Biological Foundations of Behavior	9
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
99-238	Materials, Energy and Environment	9

The following courses from the Computational Biology Department can be used to satisfy the Science and Engineering requirement and can be paired with a Biology [03-] course for two courses from one department:

02-223	Personalized Medicine: Understanding Your Own Genome	9
02-250	Introduction to Computational Biology (or 02-251 + 02-252)	12
02-261	Quantitative Cell and Molecular Biology Laboratory	9

The following MCS and CIT courses cannot be used to satisfy the Engineering and Natural Sciences requirement:

03-511	Computational Molecular Biology and Genomics	9
03-512	Computational Methods for Biological Modeling and Simulation	9
06-262	Mathematical Methods of Chemical Engineering	12
09-103	Atoms, Molecules and Chemical Change	9
09-104	Fundamental Aspects of Organic Chemistry and Biochemistry	9
09-231	Mathematical Methods for Chemists	9
12-271	Introduction to Computer Application in Civil & Environmental Engineering	9
18-090	Digital Media Interactions: Signal Processing for the Arts	10
18-200	Emerging Trends in Electrical and Computer Engineering	1
18-202	Mathematical Foundations of Electrical Engineering	12
18-213	Introduction to Computer Systems	12
18-345	Introduction to Telecommunication Networks	12
18-411	Computational Techniques in Engineering	12
18-482	Telecommunications, Technology Policy & Management	12
18-487	Introduction to Computer & Network Security & Applied Cryptography	12
18-540	Rapid Prototyping of Computer Systems	12
19-101	Introduction to Engineering and Public Policy	12
19-211	Ethics and Policy Issues in Computing	9
19-350	SP TP: Research Methods & Statistics for Engineering & Public Policy Analysis	9

19-402	Telecommunications Technology, Policy & Management	12
19-403	Policies of Wireless Systems and the Internet	12
19-411	Global Competitiveness: Firms, Nations and Technological Change	9
19-448	Science, Technology & Ethics	9
27-410	Computational Techniques in Engineering	12
33-100	Basic Experimental Physics	6
33-115	Physics for Future Presidents	9
33-124	Introduction to Astronomy	9
33-232	Mathematical Methods of Physics	10
39-100	Special Topics: WHAT IS ENGINEERING?	9
39-200	Business for Engineers	9
42-201	Professional Issues in Biomedical Engineering	3

In addition, all Electrical and Computer Engineering graduate courses [18-6xx, 18-7xx, 18-8xx, 18-9xx] cannot be used for this requirement. Consult with a CS undergraduate advisor about any course to be used for the Science and Engineering requirement before registration.

Humanities and Arts

All candidates for the bachelor's degree must complete a minimum of 63 units offered by the College of Humanities & Social Sciences and/or the College of Fine Arts as prescribed below:

A. Writing Requirement (9 units)

Complete the following course:

76-101	Interpretation and Argument	9
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B. Breadth Requirement (minimum 27 units: 9 units each)

Complete three courses, one each from Category 1, Category 2, and Category 3:

Category 1: Cognition, Choice and Behavior - this requirement explores the process of thinking, decision making, and behavior in the context of the individual.

70-311	Organizational Behavior	9
80-130	Introduction to Ethics	9
80-150	Nature of Reason	9
80-180	Nature of Language	9
80-221	Philosophy of Social Science	9
80-230	Ethical Theory	9
80-241	Ethical Judgments in Professional Life	9
80-242	Conflict and Dispute Resolution	9
80-270	Philosophy of Mind	9
80-271	Philosophy and Psychology	9
80-275	Metaphysics	9
80-281	Language and Thought	9
85-102	Introduction to Psychology	9
85-211	Cognitive Psychology	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9
85-261	Abnormal Psychology	9
88-120	Reason, Passion and Cognition	9
88-260	Organizations	9

Category 2: Economic, Political and Social Institutions - this requirement explores the processes by which institutions organize individual preferences and actions into collective outcomes.

19-101	Introduction to Engineering and Public Policy	12
36-303	Sampling, Survey and Society	9
70-332	Business, Society and Ethics	9
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
79-299	Trafficking Persons: Children in a Global Context	9
79-300	History of American Public Policy	9
79-331	Body Politics: Women and Health in America	9
80-135	Introduction to Political Philosophy	9
80-136	Social Structure, Public Policy & Ethics	9
80-235	Political Philosophy	9

80-243	Ethics of Leadership	9
80-244	Environmental Ethics	9
80-245	Medical Ethics	9
80-324	Philosophy of Economics	9
80-341	Computers, Society and Ethics	9
84-104	Decision Processes in American Political Institutions	9
84-210	Comparative Political Systems	9
84-310	International Political Economy and Organizations	9
84-320	Domestic Politics and International Affairs	9
84-322	Attitudes, the Media, and Conflict in International Relations	9
84-324	Democracies and War	9
84-362	Diplomacy and Statecraft	9
84-380	Grand Strategy in the United States	9
84-386	The Privatization of Force	9
84-393	Legislative Decision Making: U.S. Congress	9
84-402	Judicial Politics and Behavior	9
84-414	International and Subnational Security	9
84-389	Terrorism and Insurgency	9
88-110	Experiments with Economic Principles	9
88-220	Policy Analysis I	9

Category 3: Cultural Analysis - this requirement seeks to recognize cultures that have shaped and continue to shape the human experience; courses in this category are usually either broad in place, time, or cultural diversity.

57-173	Survey of Western Music History	9
60-205	Modern Visual Culture 1789-1960	9
70-342	Managing Across Cultures	9
76-227	Comedy	9
76-232	Introduction to African American Literature	9
76-239	Introduction to Film Studies	9
76-241	Introduction to Gender Studies	9
79-104	Global Histories	9
79-201	Introduction to Anthropology	9
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-207	Development of European Culture	9
79-222	Between Revolutions: The Development of Modern Latin America	9
79-226	African History: Earliest Times to 1780	9
79-229	Origins of the Arab-Israeli Conflict, 1880-1948	9
79-230	Arab-Israeli Conflict and Peace Process since 1948	9
79-240	The Development of American Culture	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-255	Irish History (must be paired with another humanities course for 9 units or more)	6
79-261	Chinese Culture and Society	9
79-262	Modern China	9
79-265	Russian History: From the First to the Last Tsar	9
79-281	Introduction to Religion	9
79-282	Europe and the World since 1800	9
79-316	Photography, the First 100 Years, 1839-1939	9
79-345	The Roots of Rock and Roll	9
79-350	Early Christianity	9
79-395	The Arts in Pittsburgh	9
79-396	Music and Society in 19th and 20th Century Europe and the U.S.	9
80-100	Introduction to Philosophy	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism	9
80-261	Empiricism and Rationalism	9

80-276	Philosophy of Religion	9
82-273	Introduction to Japanese Language and Culture	9
82-293	Introduction to Russian Culture	9
82-303	Introduction to French Culture	9
82-304	The Francophone World	9
82-327	The Emergence of the German Speaking World	9
82-333	Introduction to Chinese Language and Culture	9
82-342	Spain: Language and Culture	9
82-343	Latin America: Language and Culture	9
82-344	U.S. Latinos: Language and Culture	9
82-345	Introduction to Hispanic Literary and Cultural Studies	9

C. Humanities and Arts Electives (minimum 27 units)

Complete 3 non-technical courses of at least 9 units each from any of the departments in the College of Humanities & Social Sciences or the College of Fine Arts. Some of the courses taught in these units are considered technical courses and may not be used to satisfy this requirement. Students may combine humanities/arts courses with lower units together to form a single course of 9 units or more. Additionally, a select set of courses from Business Administration and from Environmental and Public Policy can also count for this requirement. The complete list of additions and deletions can be found at <http://www.csd.cs.cmu.edu/education/bcs/humanities-arts.html>. Consult with a CS undergraduate advisor for additional information.

Students are encouraged, but not required, to take courses from different departments to gain additional breadth and to create new opportunities for engagement with the university community.

Required Minor

A sequence of courses proscribed by the requirements of the particular department. Completion of an additional major (or dual degree) also satisfies this requirement. If permitted by the minor or second major department, courses taken in satisfaction of the minor or second major may also count toward any category other than Computer Science and Mathematics. Consult with a CS undergraduate advisor and an advisor from the department of the minor (or additional major) for specific restrictions on double counting.

Computing @ Carnegie Mellon

The following course is required of all students to familiarize them with the campus computing environment:

99-10x	Computing @ Carnegie Mellon	3
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Free Electives

A free elective is any Carnegie Mellon course. However, a maximum of nine (9) units of Physical Education and/or Military Science (ROTC) and/or Student-Led (StuCo) courses may be used toward fulfilling graduation requirements.

Summary of Degree Requirements:

Area	Courses	Units
Computer Science	14	135
Mathematics	5	49
Science/Engineering	4	36
Humanities/Arts	7	63
Minor Requirement/Free electives	8	74
Computing @ Carnegie Mellon	1	3
		360

Sample Course Sequence

Freshman Year:

Fall		Units
15-122	Principles of Imperative Computation	10
15-128	Freshman Immigration Course	1
15-131	Great Practical Ideas for Computer Scientists (optional, not required for CS major)	2
21-120	Differential and Integral Calculus	10
21-127	Concepts of Mathematics	10

76-101	Interpretation and Argument	9
99-10x	Computing Skills Workshop	3
		45
Spring		Units
15-150	Principles of Functional Programming	10
15-251	Great Theoretical Ideas in Computer Science	12
21-122	Integration and Approximation	10
xx-xxx	Science/Engineering Course	9
xx-xxx	Humanities and Arts Elective	9
		50

Sophomore Year:

Fall		Units
15-213	Introduction to Computer Systems	12
21-241	Matrices and Linear Transformations	10
xx-xxx	Science/Engineering Course	9
xx-xxx	Humanities and Arts Elective	9
xx-xxx	Minor Requirement / Free Elective	9
		49
Spring		Units
15-210	Parallel and Sequential Data Structures and Algorithms	12
xx-xxx	Computer Science: Applications Elective	9
xx-xxx	Science/Engineering Course	9
xx-xxx	Humanities and Arts Elective	9
xx-xxx	Minor Requirement / Free Elective	9
		48

Junior Year:

Fall		Units
15-451	Algorithm Design and Analysis	12
xx-xxx	Computer Science: Logic/Languages Elective	9
xx-xxx	Technical Communications Course	9
xx-xxx	Probability Course	9
xx-xxx	Minor Requirement / Free Elective	9
		48
Spring		Units
15-xxx	Computer Science: Systems Elective	12
xx-xxx	Computer Science: Algorithms/Complexity Elective	9
xx-xxx	Humanities and Arts Elective	9
xx-xxx	Minor Requirement / Free Elective	9
xx-xxx	Science/Engineering Course	9
		48

Senior Year:

Fall		Units
xx-xxx	School of Computer Science Elective	9
xx-xxx	Humanities and Arts Elective	9
xx-xxx	Minor Requirement / Free Elective	9
xx-xxx	Minor Requirement / Free Elective	9
		36
Spring		Units
xx-xxx	School of Computer Science Elective	9
xx-xxx	Humanities and Arts Elective	9
xx-xxx	Minor Requirement / Free Elective	9
xx-xxx	Minor Requirement / Free Elective	9
		36

360Minimum number of units required for the degree:

The flexibility in the curriculum allows many different schedules, of which the above is only one possibility. Some elective courses are offered only once per year (Fall or Spring). Constrained CS electives (algorithms/complexity, logic/languages, systems and applications) may be taken in any order and in any semester if prerequisites are met and seats are available. Constrained electives are shown in the specific semesters in

the schedule above as an example only. Students should consult with their academic advisor to determine the best elective options depending on course availability, their academic interests and their career goals. Additionally, the School of Computer Science offers an Additional Major in Human-Computer Interaction and an Additional Major in Robotics, as well as numerous computing-oriented minors available to majors and non-majors alike.

Undergraduate Research Thesis

Students considering going on to graduate school in Computer Science should take a wide variety of Computer Science and Mathematics courses, as well as consider getting involved in independent research as early as possible. This would be no later than the junior year and can begin even earlier. Students interested in graduate school are strongly encouraged to participate in the Undergraduate Research Thesis program. Additionally, graduate CS courses can be taken with permission of the instructor and in consultation with an academic advisor.

The goal of the Undergraduate Research Thesis Program is to introduce students to the breadth of tasks involved in independent research, including library work, problem formulation, experimentation, analysis, writing and speaking. In particular, students write a survey paper summarizing prior results in their desired area of research, present a public poster session in December of their senior year describing their current progress, present their final results in an oral summary in the year-end university-wide Undergraduate Research Symposium (Meeting of the Minds) and submit a written thesis at the end of their senior year. Students work closely with faculty advisors to plan and carry out their research. The Undergraduate Research Thesis (15-599) can start as early as the Spring semester of the junior year, and spans the entire senior year. Students receive a total of 36 units of academic credit for the thesis work. Up to 18 units can be counted toward CS elective requirements (9 per semester for 2 semesters maximum). For most students, the thesis program requires at least one semester with 18 units of thesis work, so students in this program are advised to plan their schedules carefully to ensure there is ample time to perform the required research for the thesis.

Students interested in research are urged to consult with their CS undergraduate advisor and Assistant Dean no later than the end of their sophomore year in order to plan their workload effectively. Students may also consider using Research and Innovation in Computer Science (15-300, 9 units) as their technical communications requirement since this course will introduce students to various research projects going on in the School of Computer Science that may lead to a senior thesis.

Computer Science Additional Majors and Minors

The School of Computer Science (SCS) offers an Additional Major in Computer Science, Human-Computer Interaction, and Robotics. SCS offers majors in Computational Biology (jointly with the Mellon College of Science) and Statistics and Machine Learning (jointly with the Dietrich College of Humanities and Social Sciences). SCS also offers Minors in Computer Science, Computational Biology, Human-Computer Interaction, Language Technologies, Machine Learning, Neural Computation, Robotics, and Software Engineering.

To see information for the additional majors and minors other than Computer Science, see **Additional Majors and Minors in SCS** (p. 363).

Computer Science Minor

Students interested in pursuing a minor in Computer Science should first consult with an advisor in the CS Undergraduate Office after completion of the prerequisites and core courses for application requirements.

The following courses are required for the Minor in Computer Science:

Prerequisites:		Units
15-112	Fundamentals of Programming and Computer Science	12
21-127	Concepts of Mathematics	10

Computer Science core courses:

15-122	Principles of Imperative Computation	10
15-150	Principles of Functional Programming	10
15-210	Parallel and Sequential Data Structures and Algorithms	12

One of the following Computer Science core courses:

15-213	Introduction to Computer Systems	12
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15-251	Great Theoretical Ideas in Computer Science	12
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Two additional Computer Science electives, of at least 9 units each:

CS elective courses must be 15-213 or higher, at least 9-units each. 15-221 and 15-351 cannot be used. One course can be from any SCS department, with prior approval.	18
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Note: Students who take 15-213/18-213 or 15-251 as part of another degree are required to replace this requirement in the CS minor with another CS elective (15-xxx) as defined above, for a total of 3 additional CS electives.

Double-Counting Restriction

Students pursuing a Minor in Computer Science must complete at least 6 courses from their home department, of at least 9 units each, none of which are used toward the Computer Science minor. Additionally, students may double-count a maximum of 3 courses toward all other majors and minors. Students, especially from interdisciplinary majors or with multiple majors or minors, are urged to consult with the Assistant Dean or Undergraduate Program Coordinator in the CS Undergraduate Office to determine double-counting restrictions specific to their own situations.

Computer Science Additional Major

Students interested in pursuing an additional major in Computer Science should first consult with an advisor in the CS Undergraduate Office. Students are expected to complete the requirements for the CS minor first before continuing on to the additional major. Declaration for the additional major is allowed only after all math requirements are completed and at least 75% (9 of 12) of the CS requirements (core and electives) are completed. Seats in upper-level CS courses are not guaranteed for additional majors so students should plan to be flexible in selecting constrained and general electives. Acceptance to complete a Computer Science additional major is not guaranteed and depends on student performance and seat availability.

The following courses are required for the Additional Major in Computer Science:

Math Requirements:	Units
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All of the following three courses:

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10

One of the following required Matrix Algebra courses:

21-241	Matrices and Linear Transformations	10
21-242	Matrix Theory	10

One of the following required Probability courses:

15-359	Probability and Computing	12
21-325	Probability	9
36-217	Probability Theory and Random Processes	9
36-225	Introduction to Probability Theory	9

Computer Science core (all of the following):

15-122	Principles of Imperative Computation (co-requisite: 21-127; students with no prior programming experience must take 15-112 before 15-122; some students may need to take 15-110 prior to 15-112 for additional preparation.)	10
15-150	Principles of Functional Programming	10
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-213	Introduction to Computer Systems	12
15-251	Great Theoretical Ideas in Computer Science	12
15-451	Algorithm Design and Analysis	12

One Algorithms & Complexity elective:

15-354	Computational Discrete Mathematics	12
15-355	Modern Computer Algebra	9
15-453	Formal Languages, Automata, and Computability	9
15-455	Undergraduate Complexity Theory	9
15-456	Computational Geometry	9
21-301	Combinatorics	9
21-484	Graph Theory	9

others as designated by the CS Undergraduate Program

One Logics & Languages elective:

15-312	Foundations of Programming Languages	12
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15-317	Constructive Logic	9
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15-414	Bug Catching: Automated Program Verification and Testing	9
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15-424	Foundations of Cyber-Physical Systems	12
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21-300	Basic Logic	9
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80-310	Formal Logic	9
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80-311	Undecidability and Incompleteness	9
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others as designated by the CS Undergraduate Program

One Software Systems elective:

15-410	Operating System Design and Implementation	15
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15-411	Compiler Design	15
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15-418	Parallel Computer Architecture and Programming	12
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15-440	Distributed Systems	12
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15-441	Computer Networks	12
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others as designated by the CS Undergraduate Program

One Applications elective, representing important branches of computer science:

02-510	Computational Genomics	12
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05-391	Designing Human Centered Software	12
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10-401	Introduction to Machine Learning (or 10-601 Introduction to Machine Learning)	12
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11-411	Natural Language Processing	12
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15-313	Foundations of Software Engineering	12
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15-322	Introduction to Computer Music (or 15-323 Computer Music Systems and Information Processing)	9
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15-381	Artificial Intelligence: Representation and Problem Solving	9
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15-415	Database Applications	12
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15-462	Computer Graphics	12
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16-384	Robot Kinematics and Dynamics	12
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16-385	Computer Vision	9
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others as designated by the CS Undergraduate Program

Two Computer Science electives:

These electives can be from any SCS department; 200-level or above, at least 9 units each: Computer Science [15-], Computational Biology Department [02-], Human Computer Interaction Institute [05-], Institute for Software Research [08-,17-], Machine Learning [10-], Language Technologies Institute [11-], and Robotics Institute [16-]. (NOTE: The following courses do NOT count as Computer Science electives: 02-223, 02-250, 02-261, 08-200, 15-351. Consult with the CS undergraduate office before registration to determine eligibility for this requirement.)	18
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Two Computer Science electives:

These electives can be from any SCS department; 200-level or above, at least 9 units each: Computer Science [15-], Computational Biology Department [02-], Human Computer Interaction Institute [05-], Institute for Software Research [08-,17-], Machine Learning [10-], Language Technologies Institute [11-], and Robotics Institute [16-]. (NOTE: The following courses do NOT count as Computer Science electives: 02-223, 02-250, 02-261, 08-200, 15-351. Consult with the CS undergraduate office before registration to determine eligibility for this requirement.)

One Communications course:

15-221	Technical Communication for Computer Scientists	9
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76-270	Writing for the Professions	9
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Double-Counting Restriction

Students pursuing an Additional Major in Computer Science must complete at least 6 courses from their home department, of at least 9 units each, none of which are used toward the technical requirements (computer science and mathematics) of the Computer Science major. Students, especially from interdisciplinary majors or with multiple majors or minors, are urged to consult with the Assistant Dean or Undergraduate Program Coordinator in the CS Undergraduate Office to determine double-counting restrictions specific to their own situations.

Additional Majors and Minors in the School of Computer Science

Besides Computer Science, the School of Computer Science offers additional majors in:

- Human-Computer Interaction
- Robotics

Besides Computer Science, the School of Computer Science also offers minors in:

- Computational Biology

- Human-Computer Interaction
- Language Technologies
- Machine Learning
- Neural Computation
- Robotics
- Software Engineering

To see information for the additional majors and minors other than Computer Science, see **Additional Majors and Minors in SCS** (p. 363).

SCS Policies & Procedures

School of Computer Science (SCS) Academic Standards and Actions

Grading Practices

Grades given to record academic performance in SCS are detailed under Grading Practices at <http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateacademicregulations/>

Dean's List

SCS recognizes each semester those undergraduates who have earned outstanding academic records by naming them to the Dean's List. The criterion for such recognition is a quality point average of at least 3.75 while completing a minimum of 36 factorable units and earning no incomplete grades.

Academic Actions

In the first year, quality point averages below 1.75 in either semester invoke an academic action. For all subsequent semesters an academic action will be taken if the semester quality point average or the cumulative quality point average (excluding the first year) is below 2.00.

Probation: The action of probation will be taken in the following cases based on QPA:

1. One semester of the first year is below 1.75 QPA;
2. The semester QPA of a student in good standing beyond the first year falls below 2.00.

The term of probation is one semester as a full-time student. First year students are no longer on probation at the end of the second semester if the second semester's QPA is 1.75 or above. Students in the third or subsequent semester of study are no longer on probation at the end of one semester if the semester QPA and cumulative QPA (excluding the first year) are 2.00 or above.

Probation Continued: A student who has had one semester on probation and is not yet meeting minimum requirements but whose record indicates that the standards are likely to be met at the end of the next semester of study is occasionally continued on probation. This action is normally taken only when a student's semester QPA is above 2.0 but their cumulative QPA is not yet above 2.0.

Suspension: A student who does not meet minimum standards based on QPA at the end of one semester of probation will be suspended:

- A first year student will be suspended if the QPA from each semester is below 1.75.
- A student on probation in the third or subsequent semester of study will be suspended if the semester QPA is below 2.00.

The minimum period of suspension is one academic year (two non-summer semesters). At the end of that period a student may return to school (on probation) by:

1. completing a Return from Leave form from the HUB,
2. submitting an additional written statement to the SCS Assistant Dean for Undergraduate Education, minimum one page, that outlines what the student did while on leave to address the issues that led to the suspension and that would indicate future success on return, and
3. written approval from the student's academic advisor and the Assistant Dean for Undergraduate Education, in consultation with the Office of Student Affairs and the Office of International Education as appropriate.

Students who have been suspended or have withdrawn are required to absent themselves from the campus (including residence halls and Greek houses) within a maximum of two days after the action and to remain off the campus for the duration of the time specified. This action includes debarment from part-time or summer courses at the university for the duration of the period of the action. Although suspended students may not

hold student jobs, students on academic suspension may, under certain circumstances, have a non-student job with the university. Students on disciplinary or administrative suspension may not.

Drop: This is a permanent severance. Students who have been suspended and who fail to meet minimum standards in the semester that they return to school will be dropped.

Students who have been dropped are required to absent themselves from the campus (including residence halls and Greek houses) within a maximum of two days after the action.

Other Actions: In addition to academic actions based on QPA, the Associate Dean for Undergraduate Education may place students on probation, or subsequent suspension, if they do not demonstrate reasonable progress through the core CS curriculum (e.g., not completing a CS core class after 3 attempts, or not completing the required CS 100-level core courses by the end of the sophomore year). Students are encouraged to consult with their academic advisor about any concerns with regard to lack of progress in the CS major.

The relation indicated above between probation, suspension and drop is nominal. In unusual circumstances, SCS College Council may suspend or drop a student without prior probation.

Return from Leave of Absence

SCS undergraduate students returning from a leave of absence are required to submit a Return from Leave of Absence form to the CS Undergraduate Office for approval by the student's academic advisor and the SCS Assistant Dean for Undergraduate Education. In addition, the student must also supply a letter that explains the reason for the leave, the actions that were performed during the leave to prepare the student for a successful return, and a description of the on-campus resources, if required, that would be used by the student in order to increase the likelihood of success. Students returning from a leave are also encouraged to provide two letters of support from people close to the student (e.g. family, friends, clergy, teachers, coaches, others as appropriate). Requests to return are reviewed by the student's academic advisor, the Assistant Dean and the Student Affairs liaison to determine eligibility and any resources that need to be put into place to assist the student upon return. Contact the CS Undergraduate Office for more information.

Transfer into SCS / CS Dual-degree

Undergraduate students admitted to colleges at CMU other than SCS and wishing to transfer into SCS or wishing to pursue a dual degree in Computer Science should consult with the Assistant Dean for Undergraduate Education during their first year. Students must complete 21-127, 15-122, 15-150, 15-210, 15-213, 15-251 with an overall QPA over these six courses of 3.6 or higher in order to apply for transfer or dual degree. The decision to allow transfer or dual degree will be made based on availability of space in the student's class and the student's academic performance (in the specified courses and in their courses overall if necessary) at the discretion of the Assistant Dean for Undergraduate Education. Students should consult the CS Undergraduate Program office for complete information concerning minimum requirements, instructions and deadlines.

Procedure for transfer of students from another university into SCS: A student should first apply through the Office of Admission. If the Office of Admission believes the applicant is acceptable, the student's record is sent to SCS for evaluation by the Assistant Dean for Undergraduate Education. Admission is based on seat availability, overall academic performance from the student's current institution, and the application material. It is important to note that extremely few external transfers are admitted to the SCS program at Carnegie Mellon University.

Graduation Requirements

1. A requirement for graduation is the completion of the program specified for a degree with a cumulative quality point average of 2.00 or higher for all courses taken after the first year.
2. Students must be recommended for a degree by the faculty of SCS.
3. A candidate for the bachelor's degree must complete at the University a minimum of four semesters of full-time study, or the equivalent of part-time study, comprising at least 180 units of course work.
4. Students will be required to have met all financial obligations to the university before being awarded a degree.

Modification of Graduation Requirements: A student may seek permission to modify graduation requirements by petition to the SCS College Council.

Faculty

UMUT ACAR, Associate Professor, Computer Science Department – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2012–.

VICTOR ADAMCHIK, Associate Teaching Professor, Computer Science Department – Ph.D., Byelorussian State University; Carnegie Mellon, 2000–.

YUVRAJ AGARWAL, Assistant Professor, Institute for Software Research – Ph.D., University of California, San Diego; Carnegie Mellon, 2013–.

JONATHAN ALDRICH, Associate Professor, Institute for Software Research – Ph.D., University Of Washington; Carnegie Mellon, 2003–.

VINCENT ALEVEN, Associate Professor, Human-Computer Interaction Institute – Ph.D., University Of Pittsburgh; Carnegie Mellon, 2000–.

OMEAD AMIDI, Senior Systems Scientist, Robotics Institute – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1994–.

DAVID ANDERSEN, Associate Professor, Computer Science Department – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 2005–.

JOHN ANDERSON, R.K. Mellon University Professor – Ph.D., Stanford University; Carnegie Mellon, 1978–.

DIMITRIOS APOSTOLOPOULOS, Senior Systems Scientist, Robotics Institute – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1989–.

CHRISTOPHER ATKESON, Professor, Robotics Institute – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 2000–.

JAMES BAGNELL, Associate Professor, Robotics Institute – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2004–.

MARIA FLORINA BALCAN, Associate Professor, Machine Learning Department – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2014–.

JOHN BARES, Research Professor, Robotics Institute – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1993–.

ZIV BAR-JOSEPH, Professor, Computational Biology Department – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 2003–.

MATTHEW BASS, Assistant Teaching Professor, Institute for Software Research – M.S., Carnegie Mellon University; Carnegie Mellon, 2012–.

MARCEL BERGERMAN, Systems Scientist, Robotics Institute – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2005–.

KAREN BERNTSEN, Associate Teaching Professor, Human Computer Interaction Institute – M.S., Duquesne University; Carnegie Mellon, 2005–.

JEFFREY BIGHAM, Associate Professor, Human-Computer Interaction Institute – Ph.D., University of Washington; Carnegie Mellon, 2013–.

ALAN BLACK, Professor, Language Technologies Institute – Ph.D., University Of Edinburgh; Carnegie Mellon, 1999–.

GUY BLELLOCH, Professor, Computer Science Department – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 1988–.

AVRIM BLUM, Professor, Computer Science Department – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 1991–.

LENORE BLUM, Distinguished Career Professor, Computer Science Department – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 1999–.

MANUEL BLUM, University Professor, Computer Science Department – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 1999–.

DAVID BOURNE, Principal Systems Scientist, Robotics Institute – M.S., University Of Pennsylvania; Carnegie Mellon, 1980–.

DANIEL BOYARSKI, Professor – M.F.A., Indiana University; Carnegie Mellon, 1982–.

TRAVIS BREAUX, Assistant Professor, Institute for Software Research – Ph.D., North Carolina State University; Carnegie Mellon, 2010–.

STEPHEN BROOKES, Professor, Computer Science Department – Ph.D., University College; Carnegie Mellon, 1981–.

RALF BROWN, Principal Systems Scientist, Language Technologies Institute – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1993–.

BRETT BROWNING, Senior Systems Scientist, Robotics Institute – Ph.D., University of Queensland; Carnegie Mellon, 2000–.

EMMA BRUNSKILL, Assistant Professor, Computer Science Department – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2011–.

RANDAL BRYANT, University Professor, Computer Science Department – Ph.D., Massachusetts Institute Of Technology; Carnegie Mellon, 1984–.

JAMES CALLAN, Professor, Language Technologies Institute – Ph.D., University Of Massachusetts; Carnegie Mellon, 1999–.

JAIME CARBONELL, University Professor and Director, Language Technologies Institute – Ph.D., Yale University; Carnegie Mellon, 1979–.

KATHLEEN CARLEY, Professor, Institute for Software Research – Ph.D., Harvard University; Carnegie Mellon, 1984–.

JACOBO CARRASQUEL, Associate Teaching Professor, Computer Science Department – M.S., Carnegie Mellon University; Carnegie Mellon, 1980–.

JUSTINE CASSELL, Professor, Human-Computer Interaction Institute – Ph.D., University of Chicago; Carnegie Mellon, 2010–.

HOWARD CHOSET, Professor, Robotics Institute – Ph.D., California Institute Of Technology; Carnegie Mellon, 1996–.

MICHAEL CHRISTEL, Teaching Professor, Entertainment Technology Center – Ph.D., Georgia Institute Of Technology; Carnegie Mellon, 1987–.

EDMUND CLARKE, University Professor, Computer Science Department – Ph.D., Cornell University; Carnegie Mellon, 1982–.

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Additional Majors and Minors in SCS

To see information for the additional major and minor in Computer Science, see the main **School of Computer Science** section.

Computational Biology Minor

Director: Dr. Ziv Bar-Joseph
Advisor: Phillip Compeau
Admin Coordinator: Thom Gulish

The computational biology minor is open to students in any major of any college at Carnegie Mellon. The curriculum and course requirements are designed to maximize the participation of students from diverse academic disciplines. The program seeks to produce students with both basic computational skills and knowledge in biological sciences that are central to computational biology.

Why Minor in Computational Biology?

Computational Biology is concerned with solving biological and biomedical problems using mathematical and computational methods. It is recognized as an essential element in modern biological and biomedical research. There have been fundamental changes in biology and medicine over the past two decades due to spectacular advances in high throughput data collection for genomics, proteomics and biomedical imaging. The resulting availability of unprecedented amounts of biological data demands the application of advanced computational tools to build integrated models of biological systems, and to use them to devise methods of prevent or treat disease. Computational Biologists inhabit and expand the interface of computation and biology, making them integral to the future of biology and medicine.

A minor in Computational Biology will position students well for entering the job market and graduate school in this exciting and growing field.

Admission

Students must apply for admission no later than November 30 of their senior years; an admission decision will usually be made within one month. Students are encouraged to apply as early as possible in their undergraduate careers so that the advisor of the computational biology minor can provide advice on their curriculum.

To apply, send email to Dr. Ziv Bar-Joseph and Dr. Phillip Compeau. Include in your email:

- Full name
- Andrew ID
- Preferred email address (if different)
- Your class and College/School at Carnegie Mellon
- Semester you intend to graduate
- All (currently) declared majors and minors
- Statement of purpose (maximum 1 page) — Describes why you want to take this minor and how it fits into your career goals
- Proposed schedule of courses for the minor (this is your plan, NOT a commitment)

Curriculum

The minor in computational biology requires a total of five courses: 3 core courses, 1 biology elective, and 1 computer science elective, for a **total of at least 45 units**.

Prerequisites	Units
03-121 Modern Biology	9
15-122 Principles of Imperative Computation	10
Core Classes	
02-250 Introduction to Computational Biology	12
02-261 Quantitative Cell and Molecular Biology Laboratory (03-116 Phage Genomics Research or 03-343 Experimental Techniques in Molecular Biology may be substituted for 02-261 with permission of the minor advisor)	9
plus one of the following courses:	
02-510 Computational Genomics	12

02-512 Computational Methods for Biological Modeling and Simulation	9
02-530 Cell and Systems Modeling	12

Biology Electives (one of the following):

03-231 Biochemistry I	9
03-240 Cell Biology	9
03-327 Phylogenetics	9
03-330 Genetics	9
03-362 Cellular Neuroscience	9
03-363 Systems Neuroscience	9
03-364 Developmental Neuroscience	9
03-439 Introduction to Biophysics	9
03-442 Molecular Biology	9
03-534 Biological Imaging and Fluorescence Spectroscopy	9
42-202 Physiology	9

Computer Science Electives (one of the following):

02-422 Advanced Algorithms for Computational Structural Biology	9
02-450 Automation of Biological Research	9
02-500 Undergraduate Research in Computational Biology	Var.
02-510 Computational Genomics	12
02-512 Computational Methods for Biological Modeling and Simulation	9
02-530 Cell and Systems Modeling	12
02-740 Bioimage Informatics	12
09-560 Computational Chemistry	12
10-601 Introduction to Machine Learning	12
15-381 Artificial Intelligence: Representation and Problem Solving	9
15-386 Neural Computation	9
15-415 Database Applications	12
16-721 Learning-based Methods in Vision	12

A number of graduate courses in CS and Robotics may be taken in consultation with the minor advisor.

Note: No more than two courses may be double counted with your major's core requirements. Courses in the minor may not be counted towards another SCS minor. Consult the advisor for the minor for more information.

Human-Computer Interaction Additional Major

The undergraduate major in HCI is available only as an additional major. If you have questions, please contact the Academic Program Manager at hciibachelors@cs.cmu.edu.

Human-Computer Interaction (HCI) is devoted to the design, implementation, and evaluation of interactive computer-based technology. Examples of HCI products include intelligent computer tutors, wearable computers, and highly interactive web sites. Constructing an HCI product is a cyclic, iterative process that involves at least three stages.

Human-Computer Interaction Minor

The Minor in Human-Computer Interaction will give students core knowledge about techniques for building successful user interfaces, approaches for conceiving, refining, and evaluating interfaces that are useful and useable, and techniques for identifying opportunities for computational technology to improve the quality of people's lives. The students will be able to effectively collaborate in the design, implementation, and evaluation of easy-to-use, desirable, and thoughtful interactive systems. They will be prepared to contribute to multidisciplinary teams that create new interactive products, services, environments, and systems.

The key concepts, skills and methods that students will learn in the HCI Minor include:

- Fieldwork for understanding people's needs and the influence of context
- Generative approaches to imagining many possible solutions such as sketching and "bodystorming"
- Iterative refinement of designs
- Basic visual design including typography, grids, color, and the use of images
- Implementation of interactive prototypes
- Evaluation techniques including discount and empirical evaluation methods

The HCI minor is targeted at undergraduates who expect to get jobs where they design and/or implement information technology-based systems for end users, and well as students with an interest in learning more about the design of socio-technical systems. It is appropriate for students with majors in Computer Science and Information Systems, as well as students in less software-focused majors, including Design, Architecture, Art, Business Administration, Psychology, Statistics, Decision Science, Mechanical Engineering, Electrical Engineering, English and many others in the university.

Curriculum

The only prerequisite for this Minor is an introductory-level college programming course (such as 15-110, 15-112, 15-121, or 51-257) and to be in good standing with the University.

In addition to the programming prerequisite, the Minor has required two courses—05-391 Designing Human Centered Software (DHCS) and 05-392 Interaction Design Overview (IDO)—and four electives from an approved list. The student will be required to get a grade of "C" or better in each course in order for it to count as part of the Minor. There is no final project or research required for the Minor.

Required Courses

- 05-391 Designing Human Centered Software (DHCS)¹: This course provides an overview of the most important methods taught in the Additional Major in HCI, such as Contextual Inquiry, Prototyping and Iterative Design, Heuristic Evaluation, and Think Aloud User Studies. It covers in a more abbreviated form the content of 05-410 User-Centered Research and Evaluation, 05-430 Programming Usable Interfaces, and 05-433 Programming Usable Interfaces OR Software Structures for Usable Interfaces.
- 05-392 (IDO)²: This is a new design course that will combine material from 05-651 and 05-650 for students who do not have any previous experience with design, in a form that will fit appropriately in to a one-semester format. It will be first offered in Spring 2014.

Electives

The HCI minor requires four electives from the pre-approved list of electives (<http://www.hcii.cmu.edu/undergraduate-electives>) made available at the HCII website.

Double Counting

Students may double count up to two (2) of the required courses or electives with their primary major.

Relationship between the BHCI Major and Minor

Admission

- **BHCI Major:** Application and admissions required, information on the HCII website (<http://www.hcii.cmu.edu/academics/hci-undergraduate/major>).
- **BHCI Minor:** Admissions form available at the HCII website (<http://www.hcii.cmu.edu/academics/hci-undergraduate/minor>).

Prerequisites

- **BHCI Major:**
 - Freshman-level programming (51-257 or 15-110 or 15-112 or 15-121 .
 - Statistics (introductory)
 - Cognitive Psychology
 - Interaction Design Fundamentals or Communication Design Fundamentals
- **BHCI Minor:**
 - Freshman-level programming (51-257 or 15-110 or 15-112 or 15-121 .

Core Courses

- **BHCI Major:**
 - Interaction Design Studio (IDS)
 - User Centered Research & Evaluation (UCRE)
 - HCI Programming (PUI/SSUI) and Lab
 - BHCI Project
- **BHCI Minor:**
 - Interaction Design Overview (IDO)
 - Designing Human Centered Systems (DHCS)

Electives

- **BHCI Major:** Four (4) electives (2 from defined list and 2 free electives approved by the director of the BHCI major)
- **BHCI Minor:** Four (4) electives (from defined list)

Double Counting

- **BHCI Major:** Two (2) courses with primary major.
- **BHCI Minor:** Two (2) courses with primary major.

Footnotes

¹ Alternatively, a student can take *both* the BS/MHCI empirical methods course (05-410) *and* the BS/MHCI core-programming course (either 05-430 Programming Usable Interfaces or 05-431 Software Structures for User Interfaces, along with its associated 05-433 Programming Usable Interfaces OR Software Structures for Usable Interfaces). If students take this course sequence, they would get credit for fulfilling this requirement plus one elective.

² Alternatively, students can fulfill the design requirement by taking 05-650 and 05-651. If students take this course sequence, they would get credit for fulfilling this requirement plus one elective.

These alternative ways of fulfilling the requirements for the HCI minor are designed for students who are in the HCI 2nd major who want to "downgrade" to the minor. These students can use some the courses completed for the HCI 2nd major as a way of fulfilling the requirements for the minor.

Students who are in the HCI minor right from the start are strongly encouraged to follow the regular requirements outlined above and are strongly discouraged from trying these alternative ways of fulfilling the requirements. It can be extremely difficult to get into any of the alternative courses. This is true especially for 05-650, but for other courses as well. The fact that a student in the minor has already taken 05-651 will not give priority for getting into Studio.

IDeATe Minors

Advisor: Kelly Delaney
E-mail: kellydel@andrew.cmu.edu
Website: <http://ideate.cmu.edu>

The Integrative Design, Arts and Technology (IDeATe) network offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students engage in active "learning by doing" in state-of-the-art maker spaces. The program addresses current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDeATe undergraduate curriculum consists of eight interrelated concentration areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and the arts. Four of these minors are based in the School of Computer Science:

Animation & Special effects minor

Explore the technical and artistic aspects of 3D and 2D animation in an integrated manner and within different application contexts, from film animation and special effects to interactive displays. Students interested in declaring the minor should meet with the IDeATe advisor to discuss curriculum and to make a loose plan of study.

Curriculum

One Portal Course		Units
15-104	Introduction to Computing for Creative Practice (for students in the Dietrich College of Humanities and Social Sciences, the College of Fine Arts and the Tepper School of Business. These students may take 15-112 as a substitute for 15-104)	10
62-150	Introduction to Media Synthesis and Analysis (for students in the College of Engineering, Mellon College of Science and the School of Computer Science)	10
Four Collaborative or Supportive Courses:		
15-365	Experimental Animation (or crosslisted 60-422)	12
15-463	Computational Photography	12
15-465	Animation Art and Technology (or crosslisted 60-414)	12
16-461	Experimental Capture	9
60-125	Introduction to 3D Animation (must be taken with 60-126, 6 units, for a total of 12 units)	6
60-220	Technical Character Animation	10
60-415	Advanced ETB: Animation	10
60-426	Advanced ETB: 2D Animation	10

Students may take a collaborative or supportive course from one of the other IDEATe areas as one of their four collaborative or supportive courses toward the Animation & Special Effects minor. Students may double-count at most two of their Animation & Special Effects minor courses toward other majors and minors.

Intelligent Environments Minor

Develop spaces and devices that support efficiency and high quality of experience, in contexts like daily activity, built environment, making process (from laying plaster to robot development), and arts performance.

Curriculum

One Portal Course:		Units
16-223	Introduction to Physical Computing (for students in the Dietrich College of Humanities and Social Sciences, the College of Fine Arts and the Tepper School of Business.)	10
60-223	Introduction to Physical Computing (for students in the College of Engineering, Mellon College of Science and the School of Computer Science.)	10
Four Collaborative or Supportive Courses:		
12-750	Infrastructure Management	12
16-375	Robotics for Creative Practice (or crosslisted 54-375)	10
16-455	Human-Machine Virtuosity (or crosslisted 48-530)	12
16-456	Advanced Topics in Reality Computing: The Adaptive Home (or crosslisted 48-558)	12
16-467	Human Robot Interaction	12
18-540	Rapid Prototyping of Computer Systems	12
54-371	Personalized Responsive Environments (or crosslisted 16-371)	9
60-446	Advanced SIS: Expanded Theater Fusion Studio (or crosslisted 54-498)	10

Students may take a collaborative or supportive course from one of the other IDEATe areas as one of their four collaborative or supportive courses toward the Intelligent Environments minor. Students may double-count at most two of their Intelligent Environments minor courses toward other majors and minors.

Learning Media minor

Design effective new media systems for learning using new technologies, learning science principles and media arts knowledge. Produce engaging and effective experiences from games to tangible learning tool kits and remote systems.

Curriculum

One Portal Course		Units
15-104	Introduction to Computing for Creative Practice (for students in the Dietrich College of Humanities and Social Sciences, the College of Fine Arts and the Tepper School of Business. These students may take 15-112 as a substitute for 15-104)	10
62-150	Introduction to Media Synthesis and Analysis (for students in the College of Engineering, Mellon College of Science and the School of Computer Science)	10
Four Collaborative or Supportive Courses:		
05-291	Learning Media Design	9
05-292	Learning Media Methods	6
05-418	Design Educational Games	12
05-432	Personalized Online Learning	12
05-823	E-Learning Design Principles	12
80-292	Learning Science Principles	6
85-392	Human Expertise	9

Students may take a collaborative or supportive course from one of the other IDEATe areas as one of their four collaborative or supportive courses toward the Learning Media minor. Students may double-count at most two of their Learning Media minor courses toward other majors and minors.

Physical computing minor

Build interfaces and circuitry to embed in physical contexts, such as mobile environments and new creative practice instruments.

Curriculum

One Portal Course:		Units
16-223	Introduction to Physical Computing (for students in the Dietrich College of Humanities and Social Sciences, the College of Fine Arts and the Tepper School of Business.)	10
60-223	Introduction to Physical Computing (for students in the College of Engineering, Mellon College of Science and the School of Computer Science.)	10
Four Collaborative or Supportive Courses:		
15-294	Special Topic: Rapid Prototyping Technologies	5
16-375	Robotics for Creative Practice (or crosslisted 54-375)	10
16-455	Human-Machine Virtuosity (or crosslisted 48-530)	12
18-540	Rapid Prototyping of Computer Systems	12
18-551	Digital Communication and Signal Processing Systems Design	12
18-578	Mechatronic Design	12
48-390	Physical Computing Studio	10
60-130	3-D Media Studio I Topic: Hey Robot, Let's Make Something	5
60-412	Interactive Art and Computational Design	12
60-439	Advanced SIS/CP: Hybrid Instrument Building	10
62-478	digiTOOL	6

Students may take a collaborative or supportive course from one of the other IDEATe areas as one of their four collaborative or supportive courses toward the Physical Computing minor. Students may double-count at most two of their Physical Computing minor courses toward other majors and minors.

Language Technologies Minor

Chair: Alan W. Black
E-mail: awb@cs.cmu.edu
Website: <http://www.lti.cs.cmu.edu/learn>

Human language technologies have become an increasingly central component of Computer Science in the last decade. Information retrieval, machine translation and speech technology are used daily by the general public, while text mining, natural language processing, and language-based tutoring are used regularly within more specialized professional or educational environments. The Language Technologies Minor allows students to learn about language technologies and apply them through a directed project.

Prerequisites

Prerequisites	Units
15-122 Principles of Imperative Computation	10
15-150 Principles of Functional Programming	10

Recommended

21-241 Matrices and Linear Transformations or 21-341 Linear Algebra	10
36-217 Probability Theory and Random Processes	9

Curriculum

Core Course

11-721 Grammars and Lexicons	12
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Electives (choose 3)

11-411 Natural Language Processing	12
11-441 Machine Learning for Text Mining	9
11-492 Speech Processing	12
11-711 Algorithms for NLP	12
11-731 Machine Translation	12
11-741 Machine Learning for Text Mining	12
11-751 Speech Recognition and Understanding	12
11-752 Speech II: Phonetics, Prosody, Perception and Synthesis	12
11-761 Language and Statistics	12
80-180 Nature of Language	9
or 80-280 Linguistic Analysis	

Project

A semester-long directed research project OR paper to provide hands-on experience and an in-depth study of a topic (in same area as a chosen elective) 12

Double Counting of Courses

SCS undergraduates may use 11-721 Grammars and Lexicons as an elective for their CS degree and also as a required course for the LT minor. Courses in the minor may not be counted towards another SCS minor.

Machine Learning Minor

Chair: William W. Cohen
E-mail: ml-minor@cs.cmu.edu
Website: <http://www.ml.cmu.edu/prospective-students/minor-in-machine-learning.html>

Machine learning and statistical methods are increasingly used in many application areas including natural language processing, speech, vision, robotics, and computational biology. The Minor in Machine Learning allows undergraduates to learn about the core principles of this field.

Prerequisites

Prerequisites	Units
15-122 Principles of Imperative Computation	10
21-120 Differential and Integral Calculus	10
21-122 Integration and Approximation	10
36-217 Probability Theory and Random Processes	9
36-225 Introduction to Probability Theory or 21-325 Probability	9
36-226 Introduction to Statistical Inference	9

or 36-326 Mathematical Statistics (Honors)

Core Courses

Core Courses	Units
10-601 Introduction to Machine Learning or 10-701 Introduction to Machine Learning	12
36-401 Modern Regression	9

Electives

Total of 3 courses (36 units) from:	Units
10-701 Introduction to Machine Learning	12
10-7xx certain ML grad courses as specified on the Minor web page	
10-xxx year-long supervised research	
36-315 Statistical Graphics and Visualization	9
36-402 Advanced Methods for Data Analysis	9
36-462 Special Topics: Data Mining	9
36-463 Special Topics: Multilevel and Hierarchical Models	9
36-464 Special Topics: Applied Multivariate Methods	9

Additional electives can be found on the minor electives page (<http://www.ml.cmu.edu/prospective-students/minor-electives.html>).

Double Counting

Any course in the Machine Learning minor, other than the prerequisites, may not be counted towards another SCS minor.

The Minor in Neural Computation

Director: Dr. Tai Sing Lee
Administrative Coordinator: Melissa Stupka
Website: http://www.cnbc.cmu.edu/upnc/nc_minor/

The minor in Neural Computation is an inter college minor jointly sponsored by the School of Computer Science, the Mellon College of Science, and the Dietrich College of Humanities and Social Sciences, and is coordinated by the Center for the Neural Basis of Cognition (CNBC) (<http://www.cnbc.cmu.edu>).

The Neural Computation minor is open to students in any major of any college at Carnegie Mellon. It seeks to attract undergraduate students from computer science, psychology, engineering, biology, statistics, physics, and mathematics from SCS, CIT, Dietrich College and MCS. The primary objective of the minor is to encourage students in biology and psychology to take computer science, engineering and mathematics courses, to encourage students in computer science, engineering, statistics and physics to take courses in neuroscience and psychology, and to bring students from different disciplines together to form a community. The curriculum and course requirements are designed to maximize the participation of students from diverse academic disciplines. The program seeks to produce students with both basic computational skills and knowledge in cognitive science and neuroscience that are central to computational neuroscience.

Curriculum

The minor in Neural Computation will require a total of five courses: four courses drawn from the four core areas (A: Neural Computation, B: Neuroscience, C: Cognitive Psychology, D: Intelligent System Analysis), one from each area, and one additional depth elective chosen from one of the core areas that is outside the student's major. The depth elective can be replaced by a one-year research project in computational neuroscience. No more than two courses can be double counted toward the student's major or other minors. However, courses taken for general education requirements of the student's degree are not considered to be double counted. A course taken to satisfy one core area cannot be used to satisfy the course requirement for another core area. The following listing presents a set of current possible courses in each area. Substitution is possible but requires approval by the director of the minor program.

A. Neural Computation

A. Neural Computation	Units
15-386 Neural Computation	9
15-387 Computational Perception	9
15-883 Computational Models of Neural Systems	12
85-419 Introduction to Parallel Distributed Processing	9
86-375 Computational Perception	9

Pitt-Mathematics-1800 Introduction to Mathematical Neuroscience 9

B. Neuroscience

03-362 Cellular Neuroscience 9
 03-363 Systems Neuroscience 9
 03-365 Neural Correlates of Learning and Memory 9
 42-630 Introduction to Neuroscience for Engineers (crosslisted with 18-690) 12
 85-765 Cognitive Neuroscience Var.
 Pitt-Neuroscience 1000 Introduction to Neuroscience 9
 Pitt-Neuroscience 1012 Neurophysiology 9

C. Cognitive Psychology

85-211 Cognitive Psychology 9
 85-213 Human Information Processing and Artificial Intelligence 9
 85-412 Cognitive Modeling 9
 85-414 Cognitive Neuropsychology 9
 85-419 Introduction to Parallel Distributed Processing 9
 85-426 Learning in Humans and Machines 9
 85-765 Cognitive Neuroscience Var.

D. Intelligent System Analysis

10-601 Introduction to Machine Learning 12
 15-381 Artificial Intelligence: Representation and Problem Solving 9
 15-386 Neural Computation 9
 15-387 Computational Perception 9
 15-486 Artificial Neural Networks 12
 15-494 Special Topic: Cognitive Robotics 12
 16-299 Introduction to Feedback Control Systems 12
 16-311 Introduction to Robotics 12
 16-385 Computer Vision 9
 18-290 Signals and Systems 12
 24-352 Dynamic Systems and Controls 12
 36-225 Introduction to Probability Theory 9
 36-247 Statistics for Lab Sciences 9
 36-401 Modern Regression 9
 36-410 Introduction to Probability Modeling 9
 42-631 Neural Data Analysis 9
 42-632 Neural Signal Processing 12
 86-375 Computational Perception 9
 86-631 Neural Data Analysis 9

Prerequisites

The required courses in the above four core areas require a number of basic prerequisites: basic programming skills at the level of 15-110 Principles of Computing and basic mathematical skills at the level of 21-122 Integration and Approximation or their equivalents. Some courses in Area D require additional prerequisites. Area B Biology courses require, at minimum, 03-121 Modern Biology. Students might skip the prerequisites if they have the permission of the instructor to take the required courses. Prerequisite courses are typically taken to satisfy the students' major or other requirements. In the event that these basic skill courses are not part of the prerequisite or required courses of a student's major, one of them can potentially count toward the five required courses (e.g. the depth elective), conditional on approval by the director of the minor program.

Research Requirements (Optional)

The minor itself does not require a research project. The student however may replace the depth elective with a year-long research project. In special circumstances, a research project can also be used to replace one of the five courses, as long as (1) the project is not required by the student's major or other minor, (2) the student has taken a course in each of the four core areas (not necessarily for the purpose of satisfying this minor's requirements), and (3) has taken at least three courses in this curriculum not counted toward the student's major or other minors. Students interested in participating in the research project should contact any faculty engaged in computational neuroscience or neural computation research at Carnegie Mellon or in the University of Pittsburgh. A useful webpage that provides listing of faculty in neural computation is <http://www.cnbc.cmu.edu/computational-neuroscience>. The director of the minor program will be

happy to discuss with students about their research interest and direct them to the appropriate faculty.

Fellowship Opportunities

The Program in Neural Computation (PNC) administered by the Center for the Neural Basis of Cognition currently provides 3-4 competitive full-year fellowships (\$11,000) to Carnegie Mellon undergraduate students to carry out mentored research in neural computation. The fellowship has course requirements similar to the requirements of the minor. Students do not apply to the fellowship program directly. They have to be nominated by the faculty members who are willing to mentor them. Therefore, students interested in the full-year fellowship program should contact and discuss research opportunities with any CNBC faculty at Carnegie Mellon or University of Pittsburgh working in the area of neural computation or computational neuroscience and ask for their nomination by sending email to Dr. Tai Sing Lee, who also administers the undergraduate fellowship program at Carnegie Mellon. See <http://www.cnbc.cmu.edu/fellowcompneuro> for details.

The Program in Neural Computation also offers a summer training program for undergraduate students from any U.S. undergraduate college. The students will engage in a 10-week intense mentored research and attend a series of lectures in neural computation. See the <http://www.cnbc.cmu.edu/summercompneuro> for application information.

Robotics Additional Major

Director: Dr. Howie Choset
 Administrative Coordinator: Julie Goldstein
 Website: <http://addlmajor.ri.cmu.edu/>

The Additional Major in Robotics focuses on the theme that robotics is both multidisciplinary and interdisciplinary. This means that it draws from many fields, such as mechanical engineering, computer science and electrical engineering, and it also integrates these fields in a novel manner. The foundation of this program lies in motion and control. Upon this base, sensing, cognition, and action are layered. Since robotics involves building artifacts that embody these fundamentals, foci, and systems thinking, there is a "hands-on" course requirement. These foci are brought together by a unique systems perspective special to robotics. Students will complete a capstone course that will tie together previously learned skills and knowledge.

Admission

The Additional Major in Robotics is available to all Carnegie Mellon undergraduate students. Students should apply for the Robotics Additional Major their freshman year. Students in their sophomore year may apply, provided they meet the requirements and their schedule can accommodate the courses. The application is due early February and decisions on admittance to the Additional Major will be emailed to students in time for Fall registration. Application materials include:

- Full name and email address
- Home college, year you intend to graduate, and list of all declared Majors and Minors
- Statement of purpose (maximum 1 page, single spaced, to articulate why the student wants to pursue the Robotics Additional Major)
- Proposed schedule of required courses
- Unofficial Transcript (can be downloaded from SIO)

Curriculum

Prerequisites

Calculus		Units
21-259	Calculus in Three Dimensions	9
Linear Algebra (choose one)		
18-202	Mathematical Foundations of Electrical Engineering	12
21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	10
21-260	Differential Equations	9
24-311	Numerical Methods	12
Programming in C		
15-122	Principles of Imperative Computation	10
or knowledge and experience programming in C		

Required Courses

Choose 10 courses total (one from each category plus two electives):

Overview		Units
16-311	Introduction to Robotics	12
Controls		
06-464	Chemical Engineering Process Control	9
16-299	Introduction to Feedback Control Systems	12
18-370	Fundamentals of Control	12
24-451	Feedback Control Systems	12
16-xxx	Upper-level RI course with instructor and Program Director's permission	9-12
Kinematics		
16-384	Robot Kinematics and Dynamics	12
24-355	Kinematics and Dynamics of Mechanisms (not offered regularly)	9
16-xxx	Upper-level RI course with instructor and Program Director's permission	9-12
Machine Perception		
15-463	Computational Photography	12
16-385	Computer Vision	9
16-421	Vision Sensors	12
85-370	Perception	9
16-xxx	Upper-level RI course with instructor and Program Director's permission	9-12
Cognition and Reasoning		
10-601	Introduction to Machine Learning	12
11-344	Machine Learning in Practice	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-494	Special Topic: Cognitive Robotics	12
16-xxx	Upper-level RI course with instructor and Program Director's permission	9-12
"Hands-on Course"		
15-491	Special Topic: CMRoboBits: Creating Intelligent Robots	12
16-362	Mobile Robot Programming Laboratory	12
18-578	Mechatronic Design	12
16-xxx	Upper-level RI project course e.g., 16-861 or 16-865 or independent study with instructor and Program Director's permission	9-12
Systems Engineering		
16-450	Robotics Systems Engineering	12
Capstone Course		
16-474	Robotics Capstone	12
Required Electives (choose two)		
10-601	Introduction to Machine Learning	12
11-344	Machine Learning in Practice	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-424	Foundations of Cyber-Physical Systems	12
15-462	Computer Graphics	12
15-463	Computational Photography	12
15-491	Special Topic: CMRoboBits: Creating Intelligent Robots	12
15-494	Special Topic: Cognitive Robotics	12
16-264	Humanoids	12
16-362	Mobile Robot Programming Laboratory	12
16-385	Computer Vision	9
16-421	Vision Sensors	12
16-423	Designing Computer Vision Apps	12
16-597	Undergraduate Reading and Research	Var.
18-342	Fundamentals of Embedded Systems	12
18-348	Embedded Systems Engineering	12
18-349	Embedded Real-Time Systems	12
18-549	Embedded Systems Design	12

18-578	Mechatronic Design	12
85-370	Perception	9
85-382	Consciousness and Cognition	9
85-395	Applications of Cognitive Science	9
85-412	Cognitive Modeling	9
85-419	Introduction to Parallel Distributed Processing	9
85-426	Learning in Humans and Machines	9

Students may count up to 12 units of 16-597 Undergraduate Reading and Research towards the degree requirements. A student can also take additional courses from the core; e.g., a student who takes 16-385 as a core can take 16-421 as an elective.

Graduate level Robotics courses may be used to meet elective requirement with permission from the Program Director. Graduate level Mechanical Engineering and Electrical and Computer Engineering courses that are relevant to robotics may be used to meet the elective requirement with permission from the Program Director.

A 3.0 QPA in the Additional Major curriculum is required for graduation. Courses that are taken Pass/Fail or audited cannot be counted for the Additional Major.

Double-Counting Restriction

Students are permitted to double count a maximum of six courses from their Primary Major towards the Additional Major in Robotics. CS Majors are permitted to double count a maximum of five courses from their Primary Major towards the Additional Major in Robotics.

Robotics Minor

Director: Dr. Howie Choset

Administrative Coordinator: Julie Goldstein

Website: http://www.ri.cmu.edu/education/ugrad_minor.html

The Minor in Robotics provides an opportunity for undergraduate students at Carnegie Mellon to learn the principles and practices of robotics through theoretical studies and hands-on experience with robots. The Minor is open to students in any major of any college at Carnegie Mellon. Students initially learn the basics of robotics in an introductory robotics overview course. Additional required courses teach control systems and robotic manipulation. Students also choose from a wide selection of electives in robotics, perception, computer vision, cognition and cognitive science, or computer graphics. Students have a unique opportunity to undertake independent research projects, working under the guidance of Robotics Institute faculty members; this provides an excellent introduction to robotics research for those considering graduate studies.

All Robotics Minors are required to take Introduction to Robotics (16-311). This course is designed to help students understand the big picture of what is going on in robotics through topics such as kinematics, mechanisms, motion planning, sensor based planning, mobile robotics, sensors, and vision. The minor also requires students to take a controls class and a kinematics class. These courses provide students with the necessary intuition and technical background to move on to more advanced robotics courses. In addition to the required courses, students must take 2 electives. The student must have course selection approved by the Director during the application submission process.

A 2.5 QPA in the Minor curriculum is required for graduation. Courses that are taken Pass/Fail or audited cannot be counted for the Minor.

Admission

Admission to the Undergraduate Minor in Robotics is limited to current Carnegie Mellon students. Students interested in signing up for the minor should fill out the application form (https://www-preview.ri.cmu.edu/education/apply/ugrad_appform.html).

Prerequisite

Successful candidates for the Robotics Minor will have prerequisite knowledge of C language, basic programming skills, and familiarity with basic algorithms. Students can gain this knowledge by taking 15-122 Principles of Imperative Computation.

Required Courses

Overview:		Units
16-311	Introduction to Robotics	12
Controls (choose one of the following):		
06-464	Chemical Engineering Process Control	9
24-451	Feedback Control Systems	12

18-370	Fundamentals of Control	12
16-299	Introduction to Feedback Control Systems (Computer Science)	12
16-xxx	Upper-level RI course with instructor and Program Director's permission	

Kinematics (choose one of the following):

16-384	Robot Kinematics and Dynamics	12
24-355	Kinematics and Dynamics of Mechanisms	9
16-xxx	Upper-level RI course with instructor and Program Director's permission	

Electives

Two Electives (chosen from the following):

		Units
10-601	Introduction to Machine Learning	12
11-344	Machine Learning in Practice	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-424	Foundations of Cyber-Physical Systems	12
15-462	Computer Graphics	12
15-463	Computational Photography	12
15-491	Special Topic: CMRoboBits: Creating Intelligent Robots	12
15-494	Special Topic: Cognitive Robotics	12
16-264	Humanoids	12
16-362	Mobile Robot Programming Laboratory	12
16-385	Computer Vision	9
16-421	Vision Sensors	12
16-423	Designing Computer Vision Apps	12
16-597	Undergraduate Reading and Research	Var.
18-342	Fundamentals of Embedded Systems	12
18-348	Embedded Systems Engineering	12
18-349	Embedded Real-Time Systems	12
18-549	Embedded Systems Design	12
18-578	Mechatronic Design	12
85-370	Perception	9
85-382	Consciousness and Cognition	9
85-395	Applications of Cognitive Science	9
85-412	Cognitive Modeling	9
85-419	Introduction to Parallel Distributed Processing	9
85-426	Learning in Humans and Machines	9

Graduate level Robotics courses may be used to meet the elective requirement with permission from the Program Director. Graduate level Mechanical Engineering and Electrical and Computer Engineering courses that are relevant to robotics may be used to meet the elective requirement with permission from the Program Director.

Students may count up to 12 units of 16-597 Undergraduate Reading and Research towards the degree requirements.

Double-Counting Restriction

Courses being used to satisfy the requirements for the Robotics Minor may not be counted towards another minor. Students are permitted to double count a maximum of two courses from their Major (excluding General Education requirements) towards the Minor in Robotics. Free electives are not subject to the double counting policy.

Software Engineering Minor

Co-Director: Jonathan Aldrich (jonathan.aldrich@cs.cmu.edu)

Co-Director: Claire Le Goues (clegoues@cs.cmu.edu)

Website: <http://isri.cmu.edu/education/undergrad/>

The Software Engineering minor is designed to teach the fundamental tools, techniques, and processes of software engineering. Through internships and a mentored project experience, students gain an understanding of the issues of scale and complexity that motivate software engineering tools and techniques. The core curriculum includes material both on engineering the software product and on the process, teamwork, and management skills that are essential to successful engineering. Graduates of the program should have the technical, process, and teamwork skills to be immediately productive in a mature engineering organization.

Admission

The Software Engineering Minor is open to undergraduate students in any major in the university. For priority consideration, applications are due 10 days before the beginning of Spring and Fall course registration. Students may petition the Director for admission outside this schedule.

To apply, send the directors an email. Include in your email:

- Full name
- Andrew ID
- Preferred email address (if different)
- Semester you intend to graduate
- QPA
- All (currently) declared majors and minors, or home college if no major declared
- Statement of purpose (maximum 1 page) - Describes why you want to take this minor and how it fits into your career goals
- Proposed schedule of required courses and internship (this is your plan, NOT a commitment)

Prerequisite

		Units
15-214	Principles of Software Construction: Objects, Design, and Concurrency	12

Core Course Requirements

15-313	Foundations of Software Engineering	12
15-413	Software Engineering Practicum	12

Electives

The minor requires three elective courses, one selected from each of the following categories:

1. One domain-independent course focused on technical software engineering material:

15-414	Bug Catching: Automated Program Verification and Testing	9
17-609	Global Software Development	9
17-615	Software Process Definition	9
17-619	Introduction to Real-Time Software and Systems	12
17-651	Models of Software Systems	12
17-652	Methods: Deciding What to Design	12
17-653	Managing Software Development (prereq: 15-413 or an internship)	12
17-655	Architectures for Software Systems (prereq: 15-413 or an internship)	12
17-690	Seminar in Software Process	Var.
17-xxx	Other Software Engineering graduate classes may be taken; get preapproval from the program director.	

2. One engineering-focused course with a significant software component:

15-410	Operating System Design and Implementation	15
15-412	Operating System Practicum	Var.
15-437	Web Application Development	12
15-440	Distributed Systems	12
15-441	Computer Networks	12
15-610	Engineering Distributed Systems	12
17-643	Hardware for Software Engineers	Var.
18-549	Embedded Systems Design	12
18-649	Distributed Embedded Systems	12

Other courses may be acceptable, with prior approval from the director of the minor.

3. One course that explores computer science problems related to existing and emerging technologies and their associated social, political, legal, business, and organizational contexts:

08-200	Ethics and Policy Issues in Computing	9
08-300	Constructing Appropriate Technology	12
08-532	Law of Computer Technology	9
08-533	Privacy, Policy, Law and Technology	9
08-781	Mobile and Pervasive Computing Services	9
08-801	Dynamic Network Analysis	12

08-810	Computational Modeling of Complex Socio-Technical Systems	12
15-390	Entrepreneurship for Computer Science	9
15-421	Information Security and Privacy	12
19-402	Telecommunications Technology, Policy & Management	12
19-403	Policies of Wireless Systems and the Internet	12
70-311	Organizational Behavior	9
70-414	Entrepreneurship for Engineers	9
70-421	Entrepreneurship for Computer Scientists	9
70-471	Supply Chain Management	9
88-260	Organizations	9
88-341	Organizational Communication	9
88-343	Economics of Technological Change	9
88-391	Technology and Economic Growth	9
Other courses may be acceptable, with prior approval from the director of the minor.		

Required Internship and Reflection Course

A software engineering internship of a minimum of 8 full-time weeks in an industrial setting is required. The student must be integrated into a team and exposed to industry pressures. The intern may work in development, management, quality assurance, or other relevant positions. The director of the SE minor program has sole discretion in approving an internship experience based on these criteria. Students should confirm that an internship position is appropriate before accepting it, but internships that fulfill the criteria will also be accepted after the fact.

17-413	Software Engineering Reflection Each student will write an issue-focused reflection and analysis of some personal software engineering experience, typically (but not always) based on the engineering internship above. This report must be passed by one SCS faculty member and one SE Ph.D. student, for both technical content and effective written communication. Initial course meetings will cover the reflective, writing, and speaking process. In later meetings, each student will present his or her experience through a 30-45 minute talk, which will be evaluated for communication skills and critical reflective content. This course is limited to enrollment of 16, and students who are admitted to the minor program are given first priority.	6
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Double Counting Rule

At most 2 of the courses used to fulfill the minor requirements may be counted towards any other major or minor program. This rule does not apply to 15-214 (a prerequisite for the minor) or courses counted for general education requirements.

Tepper School of Business

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 Laurie R. Weingart, Senior Associate Dean, Education
 Undergraduate Program Offices: Tepper 139
 MyTepper: <http://mytepper.tepper.cmu.edu>
<http://www.tepper.cmu.edu/prospective-students/undergraduate>

The mission of the Tepper School of Business is to improve the leadership and problem-solving capabilities of individuals so as to enhance their value to organizations and society at large. The Tepper School of Business strives for excellence in the creation and dissemination of knowledge that is grounded in scientific principles and interdisciplinary collaboration, and is directed toward improving the practice and profession of management.

History

Since its founding in 1949 by William Larimer Mellon, the Tepper School of Business at Carnegie Mellon has been a pioneer in the field of analytical decision-making and management science. Its three main activities are undergraduate education, graduate education, and research.

Today, the business school is most recognized for research and teaching in the areas of economics, finance, marketing, operations management, organizational behavior, and operations research. The School's notable contributions to the intellectual community include nine Nobel laureates. It is also ranked among the schools with the highest rate of academic citations in the fields of finance, operations/production, operations research, and organizational behavior. The academic offerings of the Tepper School of Business include undergraduate studies in business and economics, masters studies in business administration and financial engineering, and doctoral studies.

Undergraduate and graduate students gain a valuable academic foundation in the fundamental disciplines of economics, the behavioral sciences and the management sciences. In addition to emphasizing an analytical approach to problem-solving and decision-making, students integrate communication, strategic thinking and leadership into their student experience.

Educational Objectives

The Tepper School of Business is home to the Undergraduate Business Administration Program and the Undergraduate Economics Program (joint with the Marianna Brown Dietrich College of Humanities and Social Sciences). The Tepper School of Business at Carnegie Mellon endeavors to be the world leader and path-breaker in management education and research, known internationally for:

- Graduates who are capable of being high-impact business leaders, who are entrepreneurial and continue to learn, and who can harness information and technology to produce sustainable economic growth.
- Education and research programs that are innovative, interdisciplinary, information-technology intensive and international in scope, and that seamlessly build upon the core competencies of the Tepper School of Business and Carnegie Mellon University, thereby maximizing impact and value.
- A learning environment that capitalizes on the advantage of diversity of community, the open exchange of ideas, and where discovery, innovation and creativity flourish.
- Values that build upon high expectations of ethical behavior, respect for the individual, responsibility to society, dedication to work, and commitment to quality and continuous improvement.

Academic Programs

Undergraduate Degrees Offered

The Tepper School offers degrees and programs that allow students to explore particular fields within their major. These are outlined below — see the departmental sections of the catalog for further details.

Business Administration

The Undergraduate Business Administration Program at the Tepper School is among the world's elite programs for undergraduate business study and is consistently rated in the top ten undergraduate programs by US News & World Report and in the top twenty-five by Businessweek. Its reputation is based upon a rigorous academic curriculum, rich in the technical aspects of management, along with the breadth of liberal arts courses that characterizes what the best of undergraduate study means for the development of the person.

It offers the degree of Bachelor of Science in Business Administration with the following concentration areas for specialized study:

- Accounting
- Business Analytics
- Business Technology
- Entrepreneurship
- Finance
- Graphic Media Management
- International Management
- Leadership & Organizational Effectiveness
- Marketing
- Operations Management

Economics

The Undergraduate Economics Program has a unique position at Carnegie Mellon University. It is the sole undergraduate program that is a joint program of the Tepper School of Business and the Marianna Brown Dietrich College of Humanities and Social Sciences. The combination of research strength (The Tepper School has been home to nine Nobel laureates in Economics) and commitment to liberal arts and interdisciplinary studies (Dietrich College has "the most creative general education program of any American university" – New York Times) provides our undergraduates with a world-class economics program.

Economics majors are considered members of both colleges and enjoy the full support and services of both. Undergraduate economics students should consult the program's website for details about applicable Tepper School and Marianna Brown Dietrich academic policies and procedures.

The Undergraduate Economics Program offers four primary degrees (listed below). These degree programs couple prerequisites with the opportunity to tailor elective choices to enable students to develop depth in topics of particular interest to them. Potential topics include economics and policy, economics of financial markets, economics in the global market place, game theory, market design and strategy, macroeconomics (applied and/or theory), microeconomics (applied and/or theory).

- B.A. in Economics
- B.S. in Economics
- B.S. in Economics and Mathematical Sciences
- B.S. in Economics and Statistics

Minors, Additional Majors and Dual Degrees

In addition to offering major degrees, both undergraduate programs offer additional majors, dual degrees and minors to all members of the Carnegie Mellon undergraduate community. These degrees are:

- Additional Major in Business Administration
- Additional Major in Economics
- Additional Major in Economics and Statistics
- Minor in Business Administration

- Minor in Business Administration for Engineering Students
- Minor in Economics
- Minor in Innovation & Entrepreneurship

Students interested in these degrees, should consult with the appropriate Tepper School academic advisor.

First Year Experience and General Education Program

Although the undergraduate business students and the undergraduate economics students follow different first year curricula, both programs provide a broad foundation upon which students build their eventual majors. Details about the first-year experience and general education requirements for the undergraduate business students and the undergraduate economics students can be found, respectively, on the Undergraduate Business Program website (<http://tepper.cmu.edu/prospective-students/undergraduate/business>) and the Dietrich College of Humanities and Social Sciences General Education website (<http://www.hss.cmu.edu/gened>).

Study Abroad

The Undergraduate Programs encourage students to consider enriching their educational experience by studying abroad during their undergraduate tenure. Interested students should meet with their academic advisors and with the Office of International Educational advisors.

Honors Degree Programs

Both the Undergraduate Economics Program and the Undergraduate Business Administration Program encourage and offer qualified students the opportunity to participate in an honors degree program. See each program's section of the catalog for more details.

Accelerated Masters Programs

All Carnegie Mellon undergraduates with outstanding academic performance are eligible to apply to the Tepper School of Business accelerated MBA program. Students who are accepted bypass their senior year as undergraduates and earn both their bachelors degree and their MBA degree in five years. Applicants to the 3-2 program are evaluated not only on their academic achievement but also on their maturity, commitment, sense of direction, and interpersonal and communications skills. Their experiences in summer internships and their extracurricular activities are also evaluated. Admission to the MBA program is highly competitive, and 3-2 applicants compete with the entire applicant pool for spaces in the program. Students interested in the 3-2 program should read the MBA catalog, available from the Masters Admissions Office. They should also talk with their individual academic advisors concerning completion of their undergraduate requirements.

Tepper School undergraduate students are also eligible to apply to the accelerated masters programs (Masters of Arts Management, Masters in Biotechnology Management, Masters of Health Care and Policy Management, Masters of Public Policy and Management, and Masters of Information Systems) offered by the H. J. Heinz III College.

Research Centers

Website: <http://tepper.cmu.edu/our-faculty-and-research/centers/>

True to its heritage, the Tepper School commits significant resources to continuing research that advances business practice and theory. Students have the opportunity to learn from professors who spearhead internationally recognized research centers, including:

- Accelerate Leadership Center (<http://tepper.cmu.edu/our-faculty-and-research/centers/accelerate-leadership-center>)
- Carnegie Bosch Institute for Applied Studies in International Management (<http://tepper.cmu.edu/our-faculty-and-research/centers/carnegie-bosch-institute>)
- Carnegie Mellon Electricity Industry Center (<http://wpweb2.tepper.cmu.edu/electricity>)
- Center for Behavioral and Decision Research (<http://cbdr.cmu.edu>)
- Center for Marketing Technology and Information (<http://tepper.cmu.edu/our-faculty-and-research/centers/center-for-marketing-technology-and-information>)
- Center for Organizational Learning, Innovation and Knowledge (<http://wpweb2.tepper.cmu.edu/orgsci>)

- Donald H. Jones Center for Entrepreneurship (<http://tepper.cmu.edu/our-faculty-and-research/centers/donald-h-jones-center-for-entrepreneurship>)
- Green Design Institute (<http://www.cmu.edu/gdi>)
- PNC Center for Financial Services Innovation (<http://tepper.cmu.edu/our-faculty-and-research/centers/pnc-center-for-financial-services-innovation>)

Tepper School Policies and Procedures

Academic Standards

A detailed list and explanation of university-wide academic standards and practices governing undergraduate students may be found in the "Undergraduate Academic Regulations" (<http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateacademicregulations>) section of the catalog. Below you will find rules that apply specifically to the Tepper School undergraduate student.

Dean's Lists

Business Administration Program

Each semester, the Tepper School Dean's Office recognizes undergraduate Business Administration students who have earned outstanding academic records by naming them to the Dean's List.

The criteria for earning Dean's List recognition in the undergraduate Business Administration Program are: a semester QPA of at least 3.50 while completing at least 45 factorable units of coursework and earning no conditional grades (I, X) at the time that final grades are recorded.

Economics Program

Students in the Economics Programs are recognized for their outstanding records by the Dean's Office of the Marianna Brown Dietrich College of Humanities and Social Sciences. The criteria for earning Dean's List recognition in the undergraduate Economics Program are determined by the Dietrich College.

- Students who complete at least 45 factorable units and attain a semester QPA from 3.50 through 3.74 are named to the Dean's List, with Honors; if the semester QPA is 3.75 or higher, students are named to the Dean's List, with High Honors.
- Students who complete at least 36 or up to 44 factorable units and attain a semester QPA of 3.75 or higher are named to the Dean's List, with Honors.
- In addition, it is generally the case that students are not eligible for the dean's list who receive conditional grades (i.e., I [incomplete] or X [conditional failure]) at the time when final semester grades are recorded.

Academic Actions

Business Administration Program

Probation: a student earning less than a 2.00 QPA in any semester is subject to academic action and is placed on academic probation. The term of probation is one semester as a full-time student.

Students generally are removed from probation and restored to good standing after earning a semester QPA of 2.00 or better and when their cumulative QPA is 2.00 or above. Students on probation who meet this QPA criterion, but carry less than the average number of course units in a semester, may be subject to continued probation status at the Program's discretion.

Suspension: a student who does not meet minimum standards at the end of one semester of probation will be suspended. The minimum period of suspension is one academic year (two semesters). At the end of that period a student may return to school (on probation) by:

1. receiving permission in writing from the Program Director, and
2. completing a Return from Leave form (found on The HUB's website)

Students who have been suspended or have withdrawn are required to absent themselves from the campus (including residence halls and Greek houses) within a maximum of two days after the action and to remain off the campus for the duration of the time specified. This action includes debarment from part-time or summer courses at the university for the duration of the period of the action. Although suspended students may not hold student jobs, students on academic suspension may, under certain circumstances, have a non-student job with the university. Students on disciplinary or administrative suspension may not.

Drop: This is a permanent severance. A student who has been suspended and who fails to meet minimum standards in the semester that they return to school will be dropped.

Students who have been dropped are required to absent themselves from the campus (including residence halls and Greek houses) within a maximum of two days after the action.

Economics Program

Undergraduate Economics students are governed by the Dietrich College academic actions policies (p. 206).

Graduation Requirements

Students in both the Business Administration Program and the Economics Programs qualify to graduate by meeting the following conditions:

1. Complete all degree, College, and University course requirements as shown in the Undergraduate Business Administration's and Undergraduate Economics Program's sections of this catalog.
2. Be recommended for their degree by the faculty of the Tepper School.
3. Meet the University's residency requirement, detailed in the "Undergraduate Academic Regulations" (<http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateacademicregulations>) section of the catalog.
4. Meet all financial obligations to the university before being awarded a degree.

Modification of Graduation Requirements: A student may seek permission to modify graduation requirements by petition to the Program head and the Senior Associate Dean, Education.

In addition to meeting university and college graduation requirements, the Undergraduate Economics Program has the additional requirement that economics courses counting towards any economics degree must be completed with a grade of "C" or better.

Transfer into Tepper School of Business

Internal Transfers

Undergraduate students admitted to colleges at CMU other than the Tepper School and wishing to transfer into the Tepper School should consult with their current academic advisor and with an academic advisor in their program of interest. The decision to allow transfer will be made based on availability of space in the student's class and the student's academic performance. Transfer into the Tepper School of Business is determined at the program level. Current students wishing to transfer into either undergraduate program should follow the instructions provided at MyTepper (<http://mytepper.tepper.cmu.edu>).

Undergraduate Business Administration Program

Burton Hollifield, Head (Tepper 141)
 Stephen Pajewski, Executive Director (Tepper 137)
 Program Office: Tepper 139
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The Business Administration Program in the Tepper School is intended for students interested in an undergraduate management education experience that is broad, and based upon quantitative studies, and analytical reasoning, and the liberal arts as its foundation. Such a program is both intellectually strong and flexible enough to accommodate the interests of students with diverse goals, ranging from beginning a career to graduate study.

The curriculum is designed around: a central core of courses in the functional areas of business, economics, mathematics and computing course requirements. To this is added a requirement for in-depth study in one of the functional business areas such as finance, technology, marketing, entrepreneurship, or operations management. Finally, the curriculum requires all students to have a minor in order to obtain the additional breadth and flexibility that promotes confidence in one's knowledge and its benefits for a lifetime. We believe this curriculum structure is that which is needed by those who will be leaders in the increasingly global business and political environment in which organizations of the future will pursue their goals.

Our curriculum prepares students to begin their professional careers in all areas of management and they do so in some of the world's leading service, manufacturing, and governmental organizations. Many go on to graduate study in economics, finance, law, and policy studies at leading universities in the world.

In addition to the major in Business Administration, we offer the opportunity for a minor or second major to students in other programs of the university. If you are seriously interested in management education in an environment that offers the best undergraduate experience, please contact the program's academic advisors.

B.S. Degree in Business Administration

To receive the B.S. degree in Business Administration, students must complete at least 364 units, consisting of the requirements for the Business Foundation, Business Core, Concentration Area, Liberal Arts & Sciences Breadths, and a Minor.

Business Foundations

Mathematics		Units
21-120	Differential and Integral Calculus	10
21-256	Multivariate Analysis ¹	9
21-257	Models and Methods for Optimization ²	9
Economics		
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
Statistics		
70-207	Probability and Statistics for Business Applications	9
70-208	Regression Analysis	9

Computing		Units
70-110	Business Computing	9

¹ or 21-259 Calculus in Three Dimensions.

² or 21-292 Operations Research I

Business Core

Analysis & Strategy		Units
70-100	Global Business	9
70-122	Introduction to Accounting	9

70-371	Operations Management	9
70-381	Marketing I	9
70-391	Finance	9
70-401	Management Game	12

Organizational Leadership

70-201	Professional and Service Projects	9
70-311	Organizational Behavior	9
70-332	Business, Society and Ethics	9
70-340	Business Communications	9
70-345	Business Presentations	9

Concentration Areas

A program concentration area provides a focus of additional courses (both required and elective) that the student must complete in order to obtain in-depth knowledge of a particular functional area of management expertise. Students must complete at least one of the following areas.

- Accounting
- Business Analytics
- Business Technology
- Entrepreneurship
- Finance
- Graphic Media Management
- International Management
- Leadership & Organizational Effectiveness
- Marketing
- Operations Management

Accounting

REQUIRED COURSES

70-422	Managerial Accounting	9
70-424	Corporate Financial Reporting	9
70-428	Financial Statement Analysis	9

Business Analytics

ELECTIVE COURSES (choose three)

70-374	Data Mining & Business Analytics	9
70-455	Modern Data Management	9
70-460	Mathematical Models for Consulting	9
70-462	Stochastic Modeling and Simulations	9
73-363	Econometrics	9
73-365	Firms, Market Structures, and Strategy	9

Business Technology

REQUIRED COURSE

70-455	Modern Data Management	9
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ELECTIVE COURSES - choose two:

70-339	Information Technology for Finance	9
70-443	Digital Marketing and Social Media Strategy	9
70-453	Business Technology for Consulting	9

Entrepreneurship

REQUIRED COURSES:

70-415	Introduction to Entrepreneurship	9
or 70-414	Entrepreneurship for Engineers	
or 70-420	Entrepreneurship for Scientists	
or 70-421	Entrepreneurship for Computer Scientists	
70-416	New Venture Creation	9
70-438	Commercialization and Innovation	9

Finance

REQUIRED COURSES

70-492	Investment Analysis	9
70-495	Corporate Finance	9

ELECTIVE COURSES - choose one:

70-398	International Finance	9
70-496	Entrepreneurial Finance: Valuation & Deal	6
70-497	Derivative Securities	9

Graphic Media Management

REQUIRED COURSE

70-160	Graphic Media Management	9
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ELECTIVE COURSES - choose two:

70-162	Interactive Media Management	9
70-196	Publishing on the World Wide Web	9
70-347	Publishing Management in the Information Age	9
70-349	Color Reproduction & Management	9
70-514	Independent Study: Graphic Media Management	Var.

International Business

ELECTIVE COURSES - choose three plus the Independent Study

70-342	Managing Across Cultures *	9
70-365	International Trade and International Law *	9
70-430	International Management *	9
70-480	International Marketing *	9
70-508	Independent Study in International Management (This involves cultural preparation for the experience abroad)	Var.

* These requirements may be met by comparable courses taken abroad, subject to approval by the Area Advisor.

EXPERIENCE ABROAD

The International Business Area requires at least one semester of study abroad, or a substantial internship abroad (e.g., one summer or one semester), or both. Study abroad programs should provide substantial immersion in the culture. Contact the Area Advisor for assistance.

LANGUAGE REQUIREMENT

Students must demonstrate conversational proficiency in a language other than English, to the satisfaction of the Area Advisor. (This may be, but is not necessarily, the same language used during the experience abroad.) Proficiency may be demonstrated in several ways, including:

- Long-term residence in a country that requires knowledge of the language (normally the case for international students).
- Language courses, normally including at least one intensive course that lasts several weeks. A few semesters of high school or college study do not necessarily satisfy the requirement.
- Successful completion of at least one semester of courses taught in the language in a country where it is spoken, or employment that requires conversational knowledge of the language.

Leadership & Organizational Effectiveness

ELECTIVE COURSES - choose three

70-321	Negotiation and Conflict Resolution	9
70-341	Organizational Communication	9
70-342	Managing Across Cultures	9
70-437	Organizational Learning and Strategic Management	9

Marketing

REQUIRED COURSE

70-481	Marketing Research	9
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ELECTIVE COURSES - choose two:

70-385	Consumer Behavior	9
70-482	Pricing Strategy	9
70-483	Advertising and Marketing Communications	9
70-485	Product and Brand Management	9

Operations Management

REQUIRED COURSES

70-460	Mathematical Models for Consulting	9
70-471	Supply Chain Management	9

ELECTIVE COURSES - choose one course:

70-374	Data Mining & Business Analytics	9
70-462	Stochastic Modeling and Simulations	9
70-474	Quality Management and Productivity	9
70-476	Service Operations Management	9

Business Electives

Complete three upper-level Business courses (70-3xx and above) that do not double-count with any other requirement. This may include 21-270 Introduction to Mathematical Finance and upper-level Economics courses (73-3xx and above) that do not double-count with any other requirement. A second concentration area may be completed in place of this electives requirement.

Liberal Arts & Sciences Breadth Requirements

Complete seven breadth requirements. Two are first-year requirements and five are from five distributional categories, taking one course in each category.

First-Year requirements

		Units
76-101	Interpretation and Argument	9
79-104	Global Histories	9

Distributional Requirements

CATEGORY 1: SCIENCE & TECHNOLOGY. This requirement seeks to engage students in both exposure to substance, and the experience of, methods in science and technology through courses drawn from the natural and physical sciences, computer science, and engineering.

03-121	Modern Biology	9
03-132	Basic Science to Modern Medicine	9
09-103	Atoms, Molecules and Chemical Change	9
09-105	Introduction to Modern Chemistry I	10
33-104	Experimental Physics	9
33-106	Physics I for Engineering Students	12
33-111	Physics I for Science Students	12
33-115	Physics for Future Presidents	9
33-114	Physics of Musical Sound	9
33-124	Introduction to Astronomy	9
33-131	Matter and Interaction I	12
15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10
06-100	Introduction to Chemical Engineering	12
12-100	Introduction to Civil and Environmental Engineering	12
18-100	Introduction to Electrical and Computer Engineering	12
19-101	Introduction to Engineering and Public Policy	12
19-424	Energy and the Environment	9
24-101	Fundamentals of Mechanical Engineering	12
27-052	Introduction to NanoScience and Technology	9
27-100	Engineering the Materials of the Future	12
42-101	Introduction to Biomedical Engineering	12

CATEGORY 2: COGNITION, CHOICE, AND BEHAVIOR. This requirement explores the process of thinking, decision making, and behavior in the context of the individual.

80-100	Introduction to Philosophy	9
80-130	Introduction to Ethics	9
80-150	Nature of Reason	9
80-242	Conflict and Dispute Resolution	9

80-270	Philosophy of Mind	9
80-271	Philosophy and Psychology	9
80-275	Metaphysics	9
80-230	Ethical Theory	9
85-102	Introduction to Psychology	9
85-211	Cognitive Psychology	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9
85-261	Abnormal Psychology	9
88-120	Reason, Passion and Cognition	9

CATEGORY 3: POLITICAL AND SOCIAL INSTITUTIONS. This requirement presents courses that analyze, through model-based reasoning, the processes by which institutions organize individual preferences and actions into collective outcomes. Choices draw upon such disciplines as political science, history, and policy analysis.

19-101	Introduction to Engineering and Public Policy	12
79-231	American Foreign Policy: 1945-Present	9
79-300	History of American Public Policy	9
79-330	Medicine and Society	9
79-338	History of Education in America	9
84-104	Decision Processes in American Political Institutions	9
84-210	Comparative Political Systems	9
84-275	Comparative Politics	9
84-326	Theories of International Relations	9
88-220	Policy Analysis I	9

CATEGORY 4: CREATIVE PRODUCTION & REFLECTION. These courses foster creativity and provide exposure to artistic and intellectual products such as drama, literature, design, music, expository writing, and foreign languages. It also seeks to stimulate critical reflection on the process of creating, and inquiry into why one chooses certain kinds of creative productions.

48-095	Spatial Concepts for Non-Architects I	Var.
51-231	Calligraphy I	9
51-261	Communication Design Fundamentals: Design for Interactions for Communications	9
51-264	Industrial Design Fundamentals: Design for Interactions for Products	9
54-163	Production for Non Majors	6
54-191	Acting for Non-Majors	9
62-141	Black and White Photography I	10
62-142	Digital Photography I	10
62-102	Modern Dance Workshop	6

Any language course in the Department of Modern Languages (82-xxx) will satisfy this category.

CATEGORY 5: CULTURAL ANALYSIS. This requirement fosters deeper understanding of the role cultures play in shaping individual and social behaviors. Most courses in the Department of History (79-2xx or higher) or any cultural study course in the Department of Modern Languages will satisfy this requirement. The following are examples of commonly chosen courses.

79-201	Introduction to Anthropology	9
79-205	20th Century Europe	9
79-240	The Development of American Culture	9
79-241	African American History: Africa to the Civil War	9
79-255	Irish History	6
79-262	Modern China	9
79-275	Introduction to Global Studies	9
79-281	Introduction to Religion	9
79-302	Drone Warfare: Ethics, Law, Politics, History, and Strategy	6
79-303	Pittsburgh and the Transformation of Modern Urban America	6
79-305	Moneyball Nation: Data in American Life	9
79-345	The Roots of Rock and Roll	9

Minor Requirement

Complete a minor from any other academic department. Completion of a second major (or double degree) also satisfies this requirement (and also replaces the Business major's concentration area requirement). Students may double-count any Business foundation course and breadth course and up to two Business core courses with their minor or second major requirements, if permitted by the policy of the department offering the minor or second major. Consult with an advisor from the department of the minor or second major for specific restrictions on double counting.

Computing @ Carnegie Mellon

This course is required of all students for them to learn about the campus computing environment (usually taken in one's first semester of freshman year).

99-10x	Computing @ Carnegie Mellon	3
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Free Electives

A free elective is any Carnegie Mellon course that does not fulfill any of the above requirements. Within these free electives, a maximum of nine units of Physical Education and/or Military Science (ROTC) and/or Student-Led (StuCo) courses may be counted toward the total of 364 units needed to complete the B.S. degree in Business Administration.

Summary of Degree Requirements:

Area	Courses	Units
Business Foundations	9	82
Business Core	11	102
Concentration Area	3	27
Liberal Arts and Sciences Breadths	7	63
Business Electives	3	27
Minor Requirement/Free electives	7	60
Computing @ Carnegie Mellon	1	3
Total		364

Sample Four-year Course Sequence

Freshman Year

Fall		Units
21-120	Differential and Integral Calculus	10
70-100	Global Business	9
73-100	Principles of Economics	9
76-101	Interpretation and Argument	9
xx-xxx	Breadth course	9
99-101/102	Computing @ Carnegie Mellon	3
		49

Spring

		Units
21-256	Multivariate Analysis	9
70-207	Probability and Statistics for Business Applications	9
70-110	Business Computing	9
79-104	Global Histories	9
xx-xxx	Breadth course	9
		45

Sophomore Year

Fall		Units
70-122	Introduction to Accounting	9
70-208	Regression Analysis	9
70-xxx	Finance, Marketing, or Organizational Behavior	9
73-230	Intermediate Microeconomics	9

xx-xxx	Breadth course	9
		45
Spring		Units
21-257	Models and Methods for Optimization	9
70-340	Business Communications	9
73-240	Intermediate Macroeconomics	9
xx-xxx	Minor Course	9
xx-xxx	Breadth course	9
		45
Junior Year		
Fall		Units
70-371	Operations Management	9
70-xxx	Finance, Marketing, or Organizational Behavior	9
70-xxx	Finance, Marketing, or Organizational Behavior	9
70-xxx	Concentration Course	9
xx-xxx	Breadth/Minor Course	9
		45
Spring		Units
70-332	Business, Society and Ethics	9
70-345	Business Presentations	9
70-xxx	Concentration Course	9
xx-xxx	Breadth/Concentration/Minor Course	9
70-xxx	Concentration Course	9
		45

Senior Year

Fall		Units
70-201	Professional and Service Projects	9
70-xxx	Concentration Course	9
xx-xxx	Concentration/Minor/Elective Course	9
xx-xxx	Concentration/Minor/Elective Course	9
xx-xxx	Concentration/Minor/Elective Course	9
		45
Spring		Units
70-401	Management Game	12
xx-xxx	Concentration/Minor/Elective Course	9
xx-xxx	Concentration/Minor/Elective Course	9
xx-xxx	Concentration/Minor/Elective Course	9
xx-xxx	Concentration/Minor/Elective Course	9
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Additional Major in Business Administration

Students interested in pursuing an additional major in Business Administration should consult with an advisor in the Undergraduate Business Program after completion of the Business Foundations courses and at least six of the Business Core courses for application requirements and availability of space in their class year.

The following courses are required for the Additional Major:

Business Foundations

Mathematics		Units
21-120	Differential and Integral Calculus	10
21-256	Multivariate Analysis	9
21-257	Models and Methods for Optimization	9
Economics		
73-100	Principles of Economics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
Statistics		
70-207	Probability and Statistics for Business Applications	9
70-208	Regression Analysis	9

Computing		
70-110	Business Computing	9

Business Core

Analysis & Strategy		
70-122	Introduction to Accounting	9
70-371	Operations Management	9
70-381	Marketing I	9
70-391	Finance	9
70-401	Management Game	12
Organizational Leadership		
70-311	Organizational Behavior	9
70-332	Business, Society and Ethics	9
70-340	Business Communications	9
70-345	Business Presentations	9

Business Electives

Complete two upper-level Business courses (70-3xx and above).

Double-Counting Restriction

No more than two minor courses may double-count toward a student's major core requirements or an additional minor's core requirements.

Minor in Business Administration

The minor in Business Administration requires six courses: three required courses, one constrained elective, and two electives.

Required Courses

70-101	Introduction to Business Management	9
70-122	Introduction to Accounting	9
73-100	Principles of Economics	9

Constrained Elective

Choose one course.

70-311	Organizational Behavior	9
70-371	Operations Management	9
70-381	Marketing I	9
70-391	Finance	9

Elective Courses

Choose two 70-xxx courses.

The two electives must not include: 70-100 Global Business, 70-201 Professional and Service Projects, 70-207 Probability and Statistics for Business Applications, 70-208 Regression Analysis, 70-340 Business Communications, 70-345 Business Presentations, 70-350 Acting for Business, and Independent Study/Internship courses.

Some courses have prerequisites that might include specific mathematics or other Business courses. These may be found in the course descriptions and should be discussed with a Business advisor.

Students may declare the minor at any point after their freshman year by completing the minor declaration form. The form is available online at the Program's website.

Double-Counting Restriction

Students pursuing the minor in Business Administration may double-count two minor courses with requirements outside the minor.

Minor in Business Administration for Engineers

Students in the College of Engineering are permitted to meet the Business Administration minor requirements by completing the following selection of six courses.

Five Required Courses:

73-100	Principles of Economics	9
70-371	Operations Management	9

70-471	Supply Chain Management	9
21-292	Operations Research I	9
or 21-257	Models and Methods for Optimization	
70-460	Mathematical Models for Consulting	9
or 70-474	Quality Management and Productivity	

One Engineering Project Management course:

06-421	Chemical Process Systems Design	12
12-411	Project Management for Construction	9
18-510	Sensor Systems Design	12
18-525	Integrated Circuit Design Project	12
18-540	Rapid Prototyping of Computer Systems	12
18-545	Advanced Digital Design Project	12
18-549	Embedded Systems Design	12
18-551	Digital Communication and Signal Processing Systems Design	12
18-578	Mechatronic Design	12
19-451-19-452	EPP Projects-EPP Projects	24
24-370	Engineering Design I: Methods and Skills	12
27-399	Professional Development II	1
42-402	BME Design Project	9

Some courses have prerequisites that might include specific mathematics or other Business courses. These may be found in the course descriptions and should be discussed with a Business advisor.

Students may declare the minor at any point after their freshman year by completing the minor declaration form. The form is available online at the Program's website.

Double-Counting Restriction

No more than two minor courses may double-count toward a student's major core requirements or an additional minor's core requirements.

Minor in Innovation & Entrepreneurship

The minor in Innovation & Entrepreneurship is offered by the Tepper School as part of the Integrative Design, Arts and Technology (IDeATe) network. IDeATe offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students will engage in active "learning by doing" in state-of-the-art maker spaces. The program addresses current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDeATe undergraduate curriculum consists of eight interrelated concentration areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and arts: Game Design, Animation & Special Effects, Media Design, Learning Media, Sound Design, Innovation and Entrepreneurship, Intelligent Environments, and Physical Computing.

For more information about the IDeATe experience, visit <http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#ideate>

The new minor in Innovation and Entrepreneurship is a cross-university initiative that brings together STEM disciplines with arts, humanities and business.

In this minor, you will work collaboratively in hands-on explorations of the complete 21st century innovation ecosystem. You will experience integrated models of innovation that increase the likelihood of home-run products and services that will captivate society and/or the marketplace. Your contributions can fulfill deep-felt needs or connect culture and lifestyle in a way that galvanizes users and customers. Leveraging the diverse maker culture of Carnegie Mellon, this minor involves collaborative rapid prototyping and iteration.

The minor requires six courses, one under each heading below:

Portal Course

For students with no prior economics or business coursework, either one of the following:

70-101	Introduction to Business Management	9
73-100	Principles of Economics	9

For students with no prior design or product design coursework, either one of the following:

15-294	Special Topic: Rapid Prototyping Technologies	5
51-236	Information Design	9
62-478	digitOOL	6

For students with no prior programming or computer science coursework:

15-104	Introduction to Computing for Creative Practice	10
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Entrepreneurship

Choose one:

70-414	Entrepreneurship for Engineers	9
70-415	Introduction to Entrepreneurship	9
70-420	Entrepreneurship for Scientists	9
70-421	Entrepreneurship for Computer Scientists	9
70-425	Entrepreneurship for the Creative Industries	9

Venture Creation

Choose one:

70-395	Funding Entrepreneurial Ventures	9
70-416	New Venture Creation	9

Innovation Process

Choose one:

70-438	Commercialization and Innovation	9
24-884	Designing for the Internet of Things	
51-744	Research Methods for Human-Centered Design	

Product Development

49-300	Special Topic: Integrated Product Conceptualization	12
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Practice/Experience

Multiple coursework possibilities, including CIE capstone or internship in start-up or Proseed-funded project.

Double-Counting Restriction

No more than two minor courses may double-count toward a student's major core requirements or an additional minor's core requirements.

Undergraduate Business Administration Program Policies & Procedures

Transfer into Business

The undergraduate Business Administration Program accepts applications for transfer admission from any academic institution outside of Carnegie Mellon University on a limited basis. External transfer is limited to students who have just completed their first year of study in another institution. Students interested in transfer should contact Carnegie Mellon's Office of Admission.

The Program also accepts applications for transfer from current Carnegie Mellon students who are in other colleges, also on a limited basis. Freshman students will not be considered for transfer until their Spring mid-semester grades for their first year of study have been posted.

Current students interested in transferring should meet with a Business advisor to discuss their plans and qualifications. Applications are accepted in each academic year at mid-semester of the Fall and Spring terms. Successful transfer is limited by both space and academic performance criteria. Students may be denied transfer if their academic performance prior to seeking transfer indicates that they will be unable to complete degree requirements in a timely way or if they have serious academic performance deficiencies.

Transfer of Course Credit

Students may receive credit for a maximum of three courses (27 units) of course work taken at other institutions and only provided they have received prior approval to take these courses for degree credit. Students seeking an additional major may only receive credit for a maximum of two courses (18 units), and those completing a minor may only receive credit for one course (9 units) through transferred credit. No transferred credit will be awarded for any course in which the grade received is less than a B.

Students receiving 36 units or more of AP/IB/Cambridge credit towards their degree requirements will not be eligible to transfer any additional coursework unless it is for an approved study abroad experience. Credit for college courses taken prior to enrolling at Carnegie Mellon will be given at the discretion of the department.

No courses taken online will be accepted for transfer credit.

Students who have transferred into Business Administration from another institution will have used their allocation of transfer credit and will not be permitted to transfer any additional future course credit from outside Carnegie Mellon.

Pass/Fail Credit

Students may use a maximum of 9 units Pass/Fail credit towards their graduation requirement. This does not include the course 99-101/102, Computing@Carnegie Mellon.

Academic Advising

Students are required to meet with their advisor at least once each semester to ensure that they are making normal progress towards their degree. An appointment for advising may be scheduled at any time by sending a request to <http://tepper.cmu.edu/undergradapt>.

Dean's List

Students who receive a semester QPA of 3.50 or higher (with at least 45 factorable units and receiving no grades of "incomplete") will be placed on the Dean's List for that semester.

The College Honors Program

Students with outstanding records (minimum QPA of 3.75) and with at least 270 units of credit are invited to undertake an honor's thesis project under the direction of a faculty member for 18 units of credit. Students meeting these criteria are highly encouraged to consider the honor's thesis option. For more information about the honor's thesis, please contact an advisor.

Graduation Requirements

In order to graduate with the Bachelor of Science in Business Administration, students must meet all requirements specified for the program with a cumulative QPA of at least 2.00 and 364 earned units.

Students must also meet all university residence requirements and all financial obligations to the university before being awarded a degree. It is the student's responsibility to make certain they meet all of the requirements for graduation by consulting with our advising staff on a regular basis.

Full-Time Faculty

MUSTAFA AKAN, Associate Professor of Operations Management – Ph.D., Northwestern University; Carnegie Mellon, 2008–.

LAURENCE ALES, Associate Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2008–.

KATHARINE ANDERSON, Assistant Professor of Economics and Entrepreneurship – Ph.D., University of Michigan; Carnegie Mellon, 2010–.

JAY APT, Professor of Technology; Director, Carnegie Mellon Electricity Industry Center – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2000–.

LINDA ARGOTE, David M. Kirr and Barbara A. Kirr Professor of Organizational Behavior and Theory; Director, Center for Organizational Learning, Innovation and Performance – Ph.D., University of Michigan; Carnegie Mellon, 1979–.

BRANDY L. AVEN, Assistant Professor of Organizational Behavior and Theory – Ph.D., Stanford University; Carnegie Mellon, 2010–.

EGON BALAS, University Professor of Industrial Administration and Applied Mathematics; Thomas Lord Professor of Operations Research – D.Sc.Ec., University of Brussels; D.U. (Math), University of Paris; Carnegie Mellon, 1968–.

KATHRYN BARRACLOUGH, Distinguished Service Professor of Finance – Ph.D., Australian National University; Carnegie Mellon, 2015–.

ILKER BAYBARS, Dean, Carnegie Mellon University-Qatar; Deputy Dean Emeritus, Tepper School of Business; George Leland Bach Chair; Professor of Operations Management – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1979–.

ANDREW BIRD, Assistant Professor of Accounting – Ph.D., University of Toronto; Carnegie Mellon, 2013–.

PETER BOATWRIGHT, Carnegie Bosch Professor of Marketing – Ph.D., University of Chicago; Carnegie Mellon, 1997–.

ARTHUR A. BONI, The John R. Thorne Distinguished Career Professor of Entrepreneurship – Ph.D., University of California, San Diego; Carnegie Mellon, 2001–.

CLARA BURKE, Assistant Professor of Business Communication – Ph.D., University of Wisconsin-Madison; Carnegie Mellon, 2015–.

STEPHEN M. CALABRESE, Visiting Associate Professor of Economics, Carnegie Mellon University-Qatar – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–.

SOO-HAENG CHO, Associate Professor of Operations Management – Ph.D., University of California, Los Angeles; Carnegie Mellon, 2008–.

ROSALIND M. CHOW, Associate Professor of Organizational Behavior and Theory – Ph.D., Stanford University; Carnegie Mellon, 2008–.

MILTON L. COFIELD, Distinguished Service Professor of Business Management – Ph.D., University of Illinois; Carnegie Mellon, 2001–.

TAYA R. COHEN, Associate Professor of Organizational Behavior and Theory – Ph.D., University North Carolina, Chapel Hill; Carnegie Mellon, 2010–.

GERARD P. CORNUEJOLS, IBM University Professor of Operations Research – Ph.D., Cornell University; Carnegie Mellon, 1978–.

CARLOS CORONA, Assistant Professor of Accounting – Ph.D., Stanford University; Carnegie Mellon, 2010–.

W. ROBERT DALTON, Associate Teaching Professor of Economics, Emeritus – Ph.D., University of Missouri; Carnegie Mellon, 1985–.

ROBERT M. DAMMON, Dean; Professor of Financial Economics – Ph.D., University of Wisconsin, Madison; Carnegie Mellon, 1984–.

JULIA G. DEEMS, Assistant Teaching Professor of Business Management Communication – M.A. English, The Ohio State University; Carnegie Mellon, 2011–.

TIMOTHY P. DERDINGER, Assistant Professor of Economics and Strategy – Ph.D., University of Southern California; Carnegie Mellon, 2009–.

KENNETH B. DUNN, Professor of Financial Economics – Ph.D., Purdue University; Carnegie Mellon, 1979–.

S. THOMAS EMERSON, David T. and Lindsay J. Morgenthaler Distinguished Career Professor of Entrepreneurship - Carnegie Mellon University-Qatar – Ph.D., Rice University; Carnegie Mellon, 2000–.

DENNIS N. EPPLE, Thomas Lord University Professor of Economics – Ph.D., Princeton University; Carnegie Mellon, 1974–.

MARK FICHMAN, Associate Professor of Organizational Behavior and Theory – Ph.D., University of Michigan; Carnegie Mellon, 1980–.

JEFFREY GALAK, Associate Professor of Marketing – Ph.D., New York University; Carnegie Mellon, 2009–.

WOLFGANG GATTERBAUER, Assistant Professor in Information Systems – Ph.D., Vienna University of Technology; Carnegie Mellon, 2011–.

ANISHA GHOSH, Assistant Professor of Finance – Ph.D., London School of Economics; Carnegie Mellon, 2009–.

BRENT GLOVER, Assistant Professor of Finance – Ph.D., University of Pennsylvania; Carnegie Mellon, 2011–.

MARVIN GOODFRIEND, Friends of Allan Meltzer Professorship; Professor of Economics – Ph.D., Brown University; Carnegie Mellon, 2005–.

RICHARD C. GREEN, Richard M. and Margaret S. Cyert Chair; Professor of Financial Economics – Ph.D., University of Wisconsin; Carnegie Mellon, 1982–.

W. MICHAEL GRIFFIN, Executive Director, Green Design Institute; Associate Research Professor, Engineering and Public Policy, Carnegie Institute of Technology and Tepper School of Business – Ph.D., University of Rhode Island; Carnegie Mellon, 2000–.

JOACHIM RYOHEI GROEGER, Assistant Professor of Economics – Ph.D., London School of Economics; Carnegie Mellon, 2010–.

ISA E. HAFALIR, Associate Professor of Economics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2007–.

OLIVER HAHL, Assistant Professor of Organizational Behavior and Strategy – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2013–.

DALE HERSHEY, Associate Teaching Professor of Law, Emeritus - LL.B., Harvard Law School; Carnegie Mellon, 1987-.

GEOFFREY HITCH, Assistant Teaching Professor of Acting and Business Communications - M.F.A., Carnegie Mellon; Carnegie Mellon, 1992-.

BURTON HOLLIFIELD, Head, B.S. in Business Administration Program, PNC Professor of Finance; Professor of Financial Economics - Ph.D., Carnegie Mellon; Carnegie Mellon, 1998-.

JOHN HOOKER, T. Jerome Holleran Professor of Business Ethics and Social Responsibility; Professor of Operations Research; Director, Center for International Corporate Responsibility - Ph.D., Vanderbilt University; University of Tennessee; Carnegie Mellon, 1984 -.

GUOFANG HUANG, Assistant Professor of Marketing - Ph.D., John Hopkins University; Carnegie Mellon, 2013-.

YUJI IJIRI, R. M. Trueblood University Professor of Accounting and Economics, Emeritus - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1967-.

JOSEPH B. KADANE, Leonard J. Savage University Professor of Statistics and Social Sciences, Emeritus - Ph.D., Stanford University; Carnegie Mellon, 1969-.

KARAM KANG, Assistant Professor of Economics - Ph.D., University of Pennsylvania; Carnegie Mellon, 2012-.

STEPHEN A. KAROLYI, Assistant Professor Finance and Accounting - Ph.D., Yale University; Carnegie Mellon, 2014-.

SHAM KEKRE, Associate Teaching Professor of Production and Operations Management - Carnegie Mellon University- Qatar - Ph.D., University of Rochester; Carnegie Mellon, 2006-.

SUNDER KEKRE, Director, PNC Center for Financial Services Innovation; Bosch Professor of Operations Management - Ph.D., University of Rochester; Carnegie Mellon, 1984-.

ONUR KESTEN, Associate Professor of Economics - Ph.D., University of Rochester; Carnegie Mellon, 2006-.

FATMA KILINC-KARZAN, Assistant Professor of Operations Research - Ph.D., Georgia Institute of Technology; Carnegie Mellon, 2011-.

TAE WAN KIM, Assistant Professor of Ethics - Ph.D., University of Pennsylvania; Carnegie Mellon, 2012-.

CLAUDIA A. KIRKPATRICK, Associate Teaching Professor of Business Management Communication, Emerita - D.A., Carnegie Mellon University; Carnegie Mellon, 1982-.

DAVID KRACKHARDT, Professor of Organizations, H. John Heinz III College and Joint Appointment at Tepper School of Business - Ph.D., University of California, Irvine; Carnegie Mellon, 1991-.

ROBERT E. KRAUT, Herbert A. Simon Professor of Human-Computer Interaction, School of Computer Science and Joint Appointment at Tepper School of Business - Ph.D., Yale University; Carnegie Mellon, 1993-.

YAROSLAV KRYUKOV, Assistant Professor of Economics - Ph.D., Northwestern University; Carnegie Mellon, 2008-.

LARS-ALEXANDER KUEHN, Associate Professor of Finance - Ph.D., University of British Columbia; Carnegie Mellon, 2008-.

ALEXEY KUSHNIR, Assistant Professor of Economics - Ph.D., Pennsylvania State University; Carnegie Mellon, 2014-.

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DAVID L. LAMONT, Associate Teaching Professor; Director, Management Games - M.S.I.A., Carnegie Mellon University; Carnegie Mellon, 1984-.

DOKYUN LEE, Assistant Professor of Business Analytics - Ph.D., University of Pennsylvania; Carnegie Mellon, 2015-.

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JING LI, Assistant Professor of Accounting - Ph.D., Columbia University; Carnegie Mellon, 2009-.

HUI LI, Assistant Professor of Marketing - Ph.D., University of Pennsylvania; Carnegie Mellon, 2015-.

PIERRE JINGHONG LIANG, Associate Professor of Accounting - Ph.D., University of Florida; Carnegie Mellon, 1998-.

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JOHN H. MATHER, Distinguished Service Professor of Marketing - Ph.D., University of Arizona; Carnegie Mellon, 1992-.

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BENNETT T. MCCALLUM, H. J. Heinz Professor of Economics - Ph.D., Rice University; Carnegie Mellon, 1981-.

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ALLAN H. MELTZER, The Allan H. Meltzer University Professor of Political Economy - Ph.D., University of California, Los Angeles; Carnegie Mellon, 1957-.

ROBERT A. MILLER, Richard M. Cyert and Morris DeGroot Professorship in Economics and Statistics - Ph.D., University of Chicago; Carnegie Mellon, 1982-.

ROBERT T. MONROE, Director, FlexMBA Program; Associate Teaching Professor, Information Technology and Computer Science - Ph.D., Carnegie Mellon; Carnegie Mellon, 2004-.

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JOHN R. O'BRIEN, Associate Professor of Accounting and Experimental Economics - Ph.D., University of Minnesota; Carnegie Mellon, 1984 (Leave of Absence: AY 2013-14)-.

CHRISTOPHER OLIVOLA, Assistant Professor Marketing - Ph.D., Princeton University; Carnegie Mellon, 2013-.

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EVELYN M. PIERCE, Associate Teaching Professor of Business Management Communication - M.F.A., University of Pittsburgh; Carnegie Mellon, 1993-.

RONALD PLACONE, Assistant Teaching Professor of Business Communications - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2012-.

R. RAVI, Andris A. Andris A. Zoltners Professor of Business; Rohet Tolani Distinguished Professor; Professor of Operations Research and Computer Science - Ph.D., Brown University; Carnegie Mellon, 1995-.

DENISE M. ROUSSEAU, H. J. Heinz II University Professor of Organizational Behavior and Public Policy, Heinz College and Joint Appointment at Tepper School of Business - Ph.D., University of California at Berkeley; Carnegie Mellon, 1994-.

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ALAN SCHELLER-WOLF, Professor of Operations Management; Head, Ph.D. Program - Ph.D., Columbia University; Carnegie Mellon, 1996-.

NICOLA SECOMANDI, Associate Professor of Operations Management - Ph.D., University of Houston; Carnegie Mellon, 2003-.

DUANE J. SEPPI, BNY Mellon Professor of Finance; Head, Master of Science in Computational Finance Program - Ph.D., University of Chicago; Carnegie Mellon, 1986-.

PATRICK W. SILEO, Associate Dean, Carnegie Mellon University-Qatar; Associate Teaching Professor of Economics and Finance - Carnegie Mellon University-Qatar - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1999-.

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FALLAW B. SOWELL, Associate Professor of Economics – Ph.D., Duke University; Carnegie Mellon, 1988–.

CHESTER S. SPATT, Pamela R. and Kenneth B. Dunn Professor of Finance – Ph.D., University of Pennsylvania; Carnegie Mellon, 1979–.

STEPHEN E. SPEAR, Professor of Economics – Ph.D., University of Pennsylvania; Carnegie Mellon, 1982–.

KANNAN SRINIVASAN, Rohet Tolani Dish. J. Heinz II Professor of Management, Marketing, and Information Systems – Ph.D., University of California, Los Angeles; Carnegie Mellon, 1986–.

ANTHONY P. STANTON, Teaching Professor of Graphic Media Management; Director, Graphic Media Management Program – Ph.D., University of Pittsburgh; Carnegie Mellon, 1996–.

JACK DOUGLAS STECHER, Assistant Professor of Accounting – Ph.D., University of Minnesota; Carnegie Mellon, 2008–.

AUSTIN SUDBURY, Assistant Professor of Accounting – Ph.D., Ohio State University; Carnegie Mellon, 2014–.

SRIDHAR R. TAYUR, The Ford Distinguished Research Chair; Professor of Operations Management – Ph.D., Cornell University; Carnegie Mellon, 1991–.

CHRISTOPHER I. TELMER, Associate Professor of Financial Economics – Ph.D., Queen's University at Kingston (Canada); Carnegie Mellon, 1992–.

MICHAEL A. TRICK, Senior Associate Dean, Faculty and Research; Harry B. and James H. Higgins Professor of Operations Research – Ph.D., Georgia Institute of Technology; Carnegie Mellon, 1988–.

DAVID E. TUNGATE, Associate Teaching Professor of Law – LL.B., University of Illinois School of Law; Carnegie Mellon, 1991–.

WILLEM-JAN VAN HOEVE, Associate Professor of Operations Research – Ph.D., University of Amsterdam; Carnegie Mellon, 2007–.

STEPHEN VARGO, Assistant Teaching Professor, Carnegie Mellon-Qatar – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1997–.

SHU LIN WEE, Assistant Professor of Economics – Ph.D., University of Maryland; Carnegie Mellon, 2014–.

LAURIE R. WEINGART, Senior Associate Dean, Education; Carnegie Bosch Professor of Organizational Behavior and Theory – Ph.D., Northwestern University; Carnegie Mellon, 1989–.

GEORGE M. WHITE, Associate Teaching Professor of Entrepreneurship – Carnegie Mellon-Qatar – Ph.D., University of Oregon; Carnegie Mellon, 2007–.

JEFFREY R. WILLIAMS, Professor of Business Strategy – Ph.D., University of Michigan; Carnegie Mellon, 1977–.

ANITA WILLIAMS WOOLLEY, Associate Professor of Organizational Behavior and Theory – Ph.D., Harvard University; Carnegie Mellon, 2008–.

SEVIN YELTEKIN, Associate Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2005–.

M. BUMIN YENMEZ, Assistant Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2010–.

RICHARD O. YOUNG, Teaching Professor of Business Management Communication – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1985–.

ARIEL ZETLIN-JONES, Assistant Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2012–.

KAIFU ZHANG, Assistant Professor of Marketing – Ph.D., INSEAD; Carnegie Mellon, 2014–.

Visiting Faculty

SERRA BORANBAY-AKAN, Visiting Assistant Professor of Economics – Ph.D., Northwestern University; Carnegie Mellon, 2013–.

ROBERT C. BLATTBERG, Executive Director, Center for Marketing Technology and Information; Timothy W. McQuire Distinguished Service

Professor of Marketing – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2008–.

EMIN CIVI, Visiting Associate Professor, Carnegie Mellon-Qatar – Ph.D., Celal Bayar University; Carnegie Mellon, 2012–.

BENJAMIN COLLIER, Visiting Assistant Professor, Carnegie Mellon-Qatar – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2012–.

MOHAMMAD DELASAY, Post-Doctoral Fellow in Operations Management – Ph.D., University of Alberta; Carnegie Mellon, 2014–.

FUAD FAROOQI, Visiting Assistant Professor, Carnegie Mellon-Qatar – Ph.D., Richard Ivey School of Business; Carnegie Mellon, 2013–.

STARLING HUNTER, Visiting Associate Teaching Professor, Carnegie Mellon-Qatar – Ph.D., Duke University; Carnegie Mellon, 2007–.

ANTONIO MIRALLES, Visiting Assistant Professor of Economics – Ph.D., Boston University; Carnegie Mellon, 2015–.

AJIT SHARMA, Visiting Assistant Professor of Business Technologies – Ph.D., University of Michigan; Carnegie Mellon, 2015–.

PETER STUETTGEN, Visiting Assistant Professor, Carnegie Mellon-Qatar – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2012–.

WILLIAM WALLER, Post-Doctoral Fellow in Finance – Ph.D., The University of North Carolina at Chapel Hill; Carnegie Mellon, 2015–.

SHIRLEY C. WANG, Post-Doctoral Fellow in Organizational Behavior and Theory – Ph.D., Cornell University; Carnegie Mellon, 2015–.

HAKKI YAZICI, Visiting Assistant Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2015–.

Adjunct Faculty

RICHARD L. BRYANT, Adjunct Professor of Business; Executive Director, Master of Science in Computational Finance Program – M.B.A., Carnegie Mellon University; Carnegie Mellon, 1999–.

LLOYD CORDER, Adjunct Professor of Marketing – Ph.D., University of Pittsburgh; Carnegie Mellon, 2000–.

WILLIAM COURTWRIGHT, Adjunct Professor of Entrepreneurship – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–.

TIM CUNNINGHAM, Adjunct Professor of Entrepreneurship – M.A., University of California, Los Angeles; Carnegie Mellon, 2014–.

CHRIS CYNKAR, Adjunct Professor of Entrepreneurship – M.S.I.A., Carnegie Mellon University; Carnegie Mellon, 2008–.

ROBERT DALEY, Adjunct Professor of Marketing – M.B.A., Northwestern University; Carnegie Mellon, 2013–.

L. FRANK DEMMLER, Adjunct Professor of Entrepreneurship – M.B.A., University of California at Los Angeles; Carnegie Mellon, 2002–.

ROB DILLON, Adjunct Professor of Graphic Media Management – B.A., University of Pittsburgh; Carnegie Mellon, 2001–.

CLIFFORD T. EARLY, Adjunct Professor of Law – J.D., University of Pittsburgh; Carnegie Mellon, 2000–.

TAYO FABUSUYI, Adjunct Professor of Economics – M.Phil., Oxford University; Carnegie Mellon, 2014–.

CAROL B. GOLDBURG, Executive Director, Undergraduate Economics Program; Adjunct Professor of Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2005–.

ELIF INCEKARA HAFALIR, Adjunct Assistant Professor of Economics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2007–.

ELAINE HYDER, Adjunct Professor of Organizational Behavior and Theory – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2009–.

ROBERT E. KELLEY, Adjunct Professor of Organizational Behavior and Theory – Ph.D., Colorado State University; Carnegie Mellon, 1981–.

JOHN R. LANKFORD, Executive Director, Executive Education; Adjunct Professor of Marketing – M.B.A., University of Michigan; Carnegie Mellon, 1998–.

HARSH MANGLIK, Executive in Residence and Adjunct Professor of Management – M.S.I.A., Carnegie Mellon University; Carnegie Mellon, 2013–.

MELISSA MURPHY, Adjunct Professor of Marketing – B.A., University of Pittsburgh; Carnegie Mellon, 2013–.

DAVID RAMIREZ, Adjunct Professor of Business Management – M.B.A., Carnegie Mellon University; Carnegie Mellon, 2007–.

JAMES H. ROBERTS, Adjunct Professor of Law - J.D., Syracuse University School of Law; Carnegie Mellon, 2011-

PETER J. ROMAN, Adjunct Professor of Marketing - B.S., Providence College; Carnegie Mellon, 2002-

FREDERICK H. RUETER, Adjunct Professor of Economics - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1988-

JOEL STERN, Distinguished Adjunct Professor of Finance - M.B.A., University of Chicago; Carnegie Mellon, 1996-

Undergraduate Economics Program

Dennis Epple, Head of Economics
 Carol B. Goldberg, Executive Director of Undergraduate Economics
 Program Office: Tepper School of Business, Room 139
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 Advising Appointment Online Scheduler: <http://tinyurl.com/tepper-econadvising>
<http://www.tepper.cmu.edu/undergraduate-economics>

At its most fundamental level, economics is the study of how scarce resources are allocated. What will be produced and consumed, how much, and by whom? These questions are central to the well-being of people throughout the world. Economists identify, model, and analyze problems with the objective of developing practical and efficient solutions to challenges confronting society. Economists are also active participants in the processes and institutions through which economic policies are implemented. In the public arena sphere, economists contribute to design of programs and incentive systems to foster efficient implementation of policies. In the private sector, economists bring modeling and data-analytic skill to bear, both in identifying ways to enhance productive efficiency within the firm and in developing strategies to enhance effectiveness of the firm as it competes in the global marketplace. Increasingly, economists are taking advantage of advances in technology to design new exchange systems in applications as diverse as global electronic markets, kidney exchanges, pollution control, and school choice mechanisms.

Carnegie Mellon University enjoys a rich history of innovative research in the field of economics. The university has a distinctive culture that fosters collaborative, problem-oriented, theoretically rigorous, and empirically tested research. The success of this distinctive approach is manifest in the international recognition accorded past and present faculty, including nine Nobel Prizes in Economics. In the classroom, faculty bring the same rigorous, innovative approach to help develop the tremendous intellectual potential and analytic skills of students who are drawn to study economics at Carnegie Mellon. Project courses and hands-on applications in classes enable our students to gain valuable practical experience in honing their skills in economic reasoning, modeling, and data analysis.

The Undergraduate Economics Program has a unique position at Carnegie Mellon University. It is the sole undergraduate program that is a joint program of the Tepper School of Business and the Dietrich College of Humanities and Social Sciences. The combination of research strength (Tepper has been home to nine Nobel Laureates in Economics) and commitment to liberal arts and interdisciplinary studies (Dietrich has "the most creative general education program of any American university" - New York Times) provides our undergraduates with a world-class economics program.

Economics majors are considered members of both colleges and enjoy the full support and services of both. Undergraduate economics students should consult the program's website and handbook for details about applicable Tepper and Dietrich academic policies and procedures.

Educational Objectives

The Undergraduate Economics Program offers a range of degrees in economics designed to develop strong analytical skills and a solid foundation in the discipline of economics. More specifically, measurable objectives for our economics curriculum are the following:

- Students should be able to identify, explain, and use economic concepts, theories, models, and data-analytic techniques.
- Students should acquire and use knowledge of economics, mathematics, statistics, and computing flexibly in a variety of contexts, providing the foundation for success in graduate studies and careers in the public and private sectors.
- Students should be able to apply their economic tools to formulate positions on a wide range of social and economic problems and engage effectively in policy debates.
- Students should use the investigative skills necessary for conducting original economic research and participating effectively in project teams.
- Students should be able to deliver effective presentations in which they combine visual communication design with oral arguments and/or the written word.

Advising

The Undergraduate Economics Program is committed to providing students with the opportunity to have meaningful and informative discussions about their academic, intellectual, and career interests with a wide range of advisors and mentors. In college, advising meetings are not the same thing as "being sent to the principal's office" in high school. Instead, advising meetings are extended discussions which may address both immediate and long-term interests, concerns, and desires/needs. Students pursuing a degree in economics are assigned an economics advisor who meets with them on a regular basis. Any CMU undergraduate student interesting in taking an economics courses is invited to meet with an economics advisor. To facilitate scheduling advising meetings, please use the online appointment scheduler (<http://tepper.cmu.edu/undergradappt>).

The economics curriculum is cumulative; higher-level courses build upon the foundations learned in the core course. This results in students needing to be aware of course-sequencing and the schedule of classes.

Students are encouraged to meet frequently with their Undergraduate Economics Program academic advisor to ensure that their courses fulfill the requirements towards their degree and are appropriately sequenced. Historically, successful students typically checked-in with their advisor frequently and sought the advice of their academic advisor in selecting courses, pursuing additional degrees, and planning ahead for study abroad.

First-Year Advising

Most first-year students who major in economics enter the Carnegie Mellon University as Dietrich College students, and are assigned a Dietrich College Academic Advisory Center (<http://www.cmu.edu/hss/advisory-center>) (AAC) advisor. Students who are considering majoring in economics are encouraged to contact the Undergraduate Economics Program academic advisors so that they will have access to program resources; program-level advising; and the community of faculty, staff, and students.

First-year students are **not** expected to know which degree option they wish to pursue. For this reason, the first-year curricula are quite similar for the four primary degrees awarded by the program. As students become involved in their course work, participate in the extra- and co-curricular activities sponsored by the Undergraduate Economics Program, and discussions with faculty and economics advisors, the decision of which degree to pursue becomes evident.

Study Abroad

The Undergraduate Economics Program encourages students to consider enriching their undergraduate experience by studying abroad at some point during their undergraduate tenure. Studying abroad is widely defined as either study, work, internship, volunteer, or research opportunities abroad during your college career. Studying abroad provides students with not only more awareness of cultural literacies, but it further enhances their education by providing them with the opportunity to compare and contrast different economies and regimes. Many students consider their study abroad experience to be a watershed moment in their studies. With a bit of careful planning, study abroad can be worked into most any economics student's 4-year schedule.

Preparation for Professional School Programs

Many economics students will attend professional graduate school programs (e.g., DDS, JD, MBA, MD, MPP, M.Sc. Finance, etc.) immediately after graduation or within the first five years of earning their undergraduate degree. Students who are considering applying to professional graduate schools are encouraged to meet with an economics advisor early in their career at CMU. The economics advisors can provide structure and information that are invaluable during a student's intellectual and career exploration. Knowing that the choice of courses, student achievement, extra- and co-curricular activities, professional school entrance exam test scores (e.g., GMAT, LSAT, MCAT, etc.), and faculty recommendations are key determinants of acceptance into these varied programs, the economics advisors will help you plan your time at CMU.

Preparation for Ph.D. Programs in Economics

The Undergraduate Economics Program has been successful in preparing students for admission into the nation's most competitive doctoral programs. The life of a researcher (whether in academia or in the private research sector) requires a set of skills that undergraduate students will begin to acquire through course work, research, and focused conversations with faculty and advisors. Doctoral programs in economics are looking for specific analytical skills. Key determinants of acceptance into these programs are the choice of courses, student achievement, research experience, graduate school entrance exam test scores (specifically the GRE), and faculty recommendations. Students who are considering pursuing a higher academic degree are encouraged to meet an economics advisor early in their career at CMU. Interested students are encouraged to look at the B.S. in Economics and Mathematical Sciences curriculum.

Curricula

In order to accommodate students' wide variety of goals, four primary degree programs are available: Bachelor of Arts in Economics, Bachelor of Science in Economics, Bachelor of Science in Economics and Mathematical Sciences (jointly administered by the Department of Mathematics and the Undergraduate Economics Program), and Bachelor of Science in Economics and Statistics (jointly administered by the Department of Statistics and the Undergraduate Economics Program).

The four major degree programs have been designed to provide students with a solid understanding of the central theories and analytical tools of the field of economics, while maintaining the flexibility necessary to meet the needs of a diversity of career paths. The four degrees produce strong analytical thinkers who are able to model and analyze complex problems. Graduates of the Undergraduate Economics Program gain employment as economic analysts in both the private and public sectors; pursue advanced professional degrees in business, law, and public policy; as well as enter into Ph.D. programs in economics, statistics, finance, and related fields.

For students who major in other academic fields, additional major programs in Economics and in Economics and Statistics and a minor degree program in Economics are available. Information about these degrees can be found following the discussions about the major curricula.

Major Degree Requirements and Sample Schedules

In addition to completing a minimum 360 units and fulfilling both the Dietrich General Education requirements and all University requirements, recipients of an undergraduate degree in economics must complete courses in mathematics, probability and statistics, writing, economic theory, and economic analysis, as well as a set of advanced electives and other specialized courses. It is important for students to realize that degree requirements are actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Following the list of requirements for each degree are sample four-year course schedules for a student pursuing an undergraduate degree in economics. As there are many different ways of completing the requirements, students are strongly encouraged to meet with an economics advisor to tailor their courses to their own particular needs. Students are responsible for ensuring that they understand all of the program requirements and that they meet the necessary conditions for graduation. When planning course schedules, students must give consideration to all prerequisite and co-requisite requirements.

In addition to meeting university and college graduation requirements, the Undergraduate Economics Program has the additional requirement: Economics courses counting towards any economics primary degree, additional major, or minor must be completed with a grade of "C" or higher.

B.A. in Economics

The B.A. in Economics provides a strong foundation in economic analysis and quantitative methods. The curriculum's breadth incorporates the study of political, historical, and social institutions so that students may use the economic toolkit to address the current challenges humanity faces. Built into the degree is the opportunity to study political, historical, cultural, and social institutions from other CMU departments; these courses are referred to as "Special Electives". The advanced data analysis component of the B.A. in Economics Curriculum pays additional attention to ordinal data and the study of surveys. The capstone of the curriculum is the Senior Project course where students use their qualitative and quantitative skills to contribute to the body of knowledge in empirical, experimental, and/or theoretical studies. Students pursuing this degree will be well-equipped to pursue graduate work (professional and academic), enter directly into the business world, or pursue public service.

B.A. in Economics Curriculum

Total Number of Units for the Major: 173/182

Mathematics Prerequisites (19 units)

Courses	Units
21-120	Differential and Integral Calculus Passing the MCS assessment test is an acceptable alternative to completing 21-120.
21-256	Multivariate Analysis

Sophomore Economics Colloquium (1 unit)

Courses	Units
73-450	Economics Colloquium

Writing Requirement (9 units)

Courses	Units
73-270	Writing for Economists

Economic Theory Requirements (27 units)

Courses	Units
73-100	Principles of Economics
73-230	Intermediate Microeconomics
73-240	Intermediate Macroeconomics

Economic History Requirement (9 Units)

Courses	Units
73-310	Evolution of Economic Ideas and Analysis

Quantitative Analysis Requirements (36 Units)

Courses	Units
36-201	Statistical Reasoning and Practice
or 36-207	Probability and Statistics for Business Applications
or 70-207	Probability and Statistics for Business Applications
36-202	Statistical Methods
or 36-208	Regression Analysis
or 70-208	Regression Analysis
73-407	Fundamentals of Statistical Modeling
36-303	Sampling, Survey and Society

Advanced Economics Electives (36 Units)

Students must take four advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-310 Evolution of Economic Ideas and Analysis, 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium) as well as selected courses designated by the Program offered by other departments/programs. Additionally, students may work with their advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

Special Electives (27 Units)

Students must take three special elective courses in the humanities and social sciences. The complete list of courses designated as special electives is available to current students at MyTepper (<http://>

mytepper.tepper.cmu.edu). The list below is representative of the courses that qualify as "Special Electives"; this is not an exhaustive list of qualifying courses. In particular, the graduate courses from Heinz College which open to B.A. in Economics students are not presented.

Course List

Representative List of Special Elective Courses		Units
79-221	Development and Democracy in Latin America	9
79-245	Capitalism and Individualism in American Culture	9
79-246	Industrial America	9
79-266	Russian History: From Communism to Capitalism	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-300	History of American Public Policy	9
79-392	History of Modern Warfare	9
79-384	Garbage Gone Global: Managing Waste in an Age of Mass Consumption	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
80-130	Introduction to Ethics	9
80-136	Social Structure, Public Policy & Ethics	9
80-221	Philosophy of Social Science	9
80-235	Political Philosophy	9
88-260	Organizations	9
80-305	Rational Choice	9
80-321	Causation, Law, and Social Policy	9
80-337	Philosophy, Politics & Economics	9
80-348	Health Development and Human Rights	9
84-310	International Political Economy and Organizations	9
88-365	Behavioral Economics and Public Policy	9
88-387	Social Norms and Economics	9
88-411	Rise of the Asian Economies	9
88-412	Energy, Climate Change, and Economic Growth in the 21st Century	9

Senior Work (9 Units; 18 Units for students working on an honors thesis in economics)

	Units
73-497 Senior Project	9
or 73-500 Tepper College Honors Thesis I & 73-501 and Tepper College Honors Thesis II	
or 66-501 H&SS Senior Honors Thesis I & 66-502 and H&SS Senior Honors Thesis II	

Sample Schedule for B.A. in Economics

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; and 2) room has been built into the schedule that would allow students to pick up additional degrees and/or study abroad. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
36-201 Statistical Reasoning and Practice	36-202 Statistical Methods	73-450 Economics Colloquium	73-407 Fundamentals of Statistical Modeling
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis**	"Special Elective"	Economics Elective
-----*	-----	-----	-----
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Junior		Senior	
Fall	Spring	Fall	Spring
73-310 Evolution of Economic Ideas and Analysis	36-303 Sampling, Survey and Society	73-497 Senior Project	Economics Elective
73-270 Writing for Economists	Economics Elective	Economics Elective	----
"Special Elective"	"Special Elective"	----	----
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*In each semester, ----- represents courses that are not directly required for the major.

** While not required, 73-155 is strongly recommended.

B.S. in Economics

The B.S. in Economics provides a strong foundation in economic theory and advanced quantitative analysis. The curriculum focuses on using "real-world" data to forecast behavior and to investigate the relationships between observed phenomenon and economic models. Combining these sophisticated economic modeling data analytic skills with our wide range of upper-level economic electives provides students with a rigorous analytical foundation that will allow them to pursue any career that interests them. The capstone of the curriculum is the Senior Project course where students use their qualitative and quantitative skills to contribute to the body of knowledge in empirical, experimental, and/or theoretical studies. Students completing this degree will be well-equipped to pursue graduate work (professional and academic) or enter directly into the business world or public service.

B.S. in Economics Curriculum

Total Number of Units for the Major	156/165
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Mathematics Requirement (29 Units)

	Units
21-120 Differential and Integral Calculus Passing the MCS assessment test is an acceptable alternative to completing 21-120.	10
21-256 Multivariate Analysis	9
or 21-259 Calculus in Three Dimensions	
21-122 Integration and Approximation *	10
or 21-127 Concepts of Mathematics	
or 21-257 Models and Methods for Optimization	
*Students are encouraged to meet with an economics advisor to determine which course best fits their interests	

Sophomore Colloquium (1 Unit)

	Units
73-450 Economics Colloquium	1

Quantitative Analysis Requirements (27 Units)

	Units
36-225 Introduction to Probability Theory	9
or 36-217 Probability Theory and Random Processes	
or 21-325 Probability	
73-274 Econometrics I	9
73-374 Econometrics II	9

Writing Requirement (9 Units)

	Units
73-270 Writing for Economists	9

Economic Theory Requirements (27 Units)

	Units
73-100 Principles of Economics	9
73-230 Intermediate Microeconomics	9

73-240 Intermediate Macroeconomics 9

Advanced Economics Electives (54 Units)

Students must take six advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium). For the purpose of these requirements, the Undergraduate Economics Program may also designate as advanced electives courses from other departments/programs. Additionally, students may work with their advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

Senior Work (9 Units; 18 Units for students working on an honors thesis in economics)

	Units
73-497 Senior Project	9
or 73-500 & 73-501 Tepper College Honors Thesis I and Tepper College Honors Thesis II	
or 66-501 & 66-502 H&SS Senior Honors Thesis I and H&SS Senior Honors Thesis II	

Sample Course Schedule for the B.S. in Economics

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; and 2) room has been built into the schedule that would allow students to pick up additional degrees and/or study abroad. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	73-240 Intermediate Macroeconomics
36-201 Statistical Reasoning and Practice	73-155 Legonomics: Building Blocks of Economic Analysis**	73-230 Intermediate Microeconomics	73-274 Econometrics I
73-100 Principles of Economics	-----	73-450 Economics Colloquium	Economics Elective
-----*	-----	Third Mathematics Course	-----
-----	-----	-----	-----

Junior		Senior	
Fall	Spring	Fall	Spring
73-270 Writing for Economists	Economics Elective	73-497 Senior Project	Economics Elective
73-374 Econometrics II	Economics Elective	Economics Elective	-----
Economics Elective	-----	-----	-----
-----	-----	-----	-----
-----	-----	-----	-----

*In each semester, ----- represents courses not directly required for the major.

**While not required, 73-155 is strongly recommended.

B.S. in Economics and Mathematical Sciences

The B.S. in Economics and Mathematical Sciences is a collaborative effort between the Department of Mathematical Sciences and the Undergraduate Economics Program. Combining advanced mathematics with advanced economic theory is the hallmark of this curriculum. The curriculum provides students with courses that complement and develop depth of understanding of economic theory, applied economics, and applied mathematics. This degree offers an integrated curriculum, guiding students through a program of coursework that exploits and builds upon the synergies between mathematics and economics. This degree program equips students with the mathematical tools that are essential for success in Ph.D. programs in economics; mathematics; and key functional areas of business including finance, accounting, marketing, and information systems. Students pursuing this degree will be well prepared for the beginning of their research careers in academia, government, and industry. There are a limited number of

student openings in this program; interested students may apply as early as their sophomore year. The application process may include a discussion with the Department of Mathematics's Director of Undergraduate Studies and the Undergraduate Economics Program's Executive Director; a Carnegie Mellon faculty recommendation; and a completed application submission (The application requests information about academic achievement, potential research interests, academic and/or research recognition, and meta-curricular activities. Details may be found at MyTepper (<http://mytepper.tepper.cmu.edu>)). Acceptance into the degree program is based on academic performance, rigor of coursework, and initiative while at Carnegie Mellon. In order to graduate with the B.S. in Economics and Mathematical Sciences, students must maintain a cumulative Q.P.A. of 3.33.

B.S. in Economics and Mathematical Sciences Curriculum

Total Number of Units for the Major 230

Economic Theory Requirements (27 Units)

	Units
73-100 Principles of Economics	9
73-230 Intermediate Microeconomics	9
73-240 Intermediate Macroeconomics	9

Quantitative Analysis Requirements (36 Units)

	Units
36-225 Introduction to Probability Theory	9
or 36-217 Probability Theory and Random Processes	
or 21-325 Probability	
36-226 Introduction to Statistical Inference	9
36-401 Modern Regression	9
73-374 Econometrics II	9

Mathematical Sciences Requirements (85 Units)

	Units
21-120 Differential and Integral Calculus	10
Passing the MCS assessment test is an acceptable alternative to completing 21-120.	
21-122 Integration and Approximation	10
21-127 Concepts of Mathematics	10
21-228 Discrete Mathematics	9
21-241 Matrices and Linear Transformations	10
21-259 Calculus in Three Dimensions	9-10
or 21-256 Multivariate Analysis	
or 21-268 Multidimensional Calculus	
or 21-269 Vector Analysis	
21-260 Differential Equations	9
21-355 Principles of Real Analysis I	9
21-356 Principles of Real Analysis II	9

Programming Requirement (10 Units)

	Units
15-110 Principles of Computing	10

Writing Requirement (9 Units)

	Units
73-270 Writing for Economists	9

Advanced Economic Electives (36 Units)

Students must take four advanced economics elective courses. Advanced Elective courses are those courses numbered 73-300 through 73-495, (excluding 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium) as well as courses designated by the Undergraduate Economics Program which are offered by other departments/programs. Students are encouraged to work with their advisors to structure a set of courses which meet these requirements based on their particular interests, subject to course availability.

Recommended Advanced Economics Electives:

73-310 Evolution of Economic Ideas and Analysis	9
73-315 Market Design	9

73-338	Financial Crises and Risk	9
73-347	Game Theory for Economists	9

Mathematical Science Depth Electives (27 Units)

Students must take three advanced mathematics depth courses. Students are encouraged to work with their advisors to structure a set of courses which meet these requirements based on their particular interests, subject to course availability.

Recommended Mathematical Science Depth Electives:

21-292	Operations Research I	9
21-329	Set Theory	9
21-365	Projects in Applied Mathematics	9
21-366	Topics in Applied Mathematics	9
21-371	Functions of a Complex Variable	9
21-374	Field Theory	9
21-441	Number Theory	9
21-484	Graph Theory	9
21-499	Undergraduate Research Topic	9

Note: Only one of the following three courses may count towards the required Mathematical Sciences Depth Electives: 21-365, 21-366, or 21-499.

Sample Course Schedule for the B.S. in Economics and Mathematical Sciences

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; 2) room has built into the schedule that would allow students to pick up additional degrees and/or study abroad; and 3) the demands of this degree require students to carefully plan their degree program while keeping in mind the college-level and university-level graduation requirements. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	15-110 Principles of Computing	21-122 Integration and Approximation	21-241 Matrices and Linear Transformations
36-201 Statistical Reasoning and Practice	21-256 Multivariate Analysis	21-127 Concepts of Mathematics	36-226 Introduction to Statistical Inference
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis**	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
-----*	-----	36-225 Introduction to Probability Theory	Economics Elective
-----	-----	-----	-----

Junior		Senior	
Fall	Spring	Fall	Spring
21-260 Differential Equations	21-355 Principles of Real Analysis I	21-228 Discrete Mathematics	21-356 Principles of Real Analysis II
73-374 Econometrics II	Economics Elective	36-401 Modern Regression	-----
73-270 Writing for Economists	Economics Elective	Mathematics Elective	-----
Economics Elective	Mathematics Elective	-----	-----
Mathematics Elective	-----	-----	-----

*In each semester, ----- represents courses not directly required for the major. Please note that students pursuing the B.S. in Mathematical Sciences and Economics must fulfill the Mellon College General Education requirements and not the Dietrich College General Education requirements.

**While not required, 73-155 is strongly recommended.

B.S. in Economics and Statistics

Academic Advisor: Paige Houser
 For questions about Economics courses contact: Carol Goldberg or Kathleen Conway
 For questions about Statistics courses contact: Rebecca Nugent or Paige Houser
 Office: Baker Hall 132A

Email: acadcoord@stat.cmu.edu

The Major in Economics and Statistics provides an interdisciplinary course of study aimed at students with a strong interest in the empirical analysis of economic data. With joint curriculum from the Department of Statistics and the Undergraduate Economics Program, the major provides students with a solid foundation in the theories and methods of both fields. Students in this major are trained to advance the understanding of economic issues through the analysis, synthesis and reporting of data using the advanced empirical research methods of statistics and econometrics. Graduates are well positioned for admission to competitive graduate programs, including those in statistics, economics and management, as well as for employment in positions requiring strong analytic and conceptual skills - especially those in economics, finance, education, and public policy.

The requirements for the B.S. in Economics and Statistics are the following:

I. Prerequisites 38-39 units

1. Mathematical Foundations 38-39 units

Calculus

21-120 Differential and Integral Calculus 10

and one of the following three:

21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
21-257	Models and Methods for Optimization	9

and one of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

Note: Passing the MSC 21-120 assessment test is an acceptable alternative to completing 21-120.

Note: Taking both 21-111 and 21-112 is equivalent to 21-120. The Mathematical Foundations total is then 48-49 units. The Economics and Statistics major would then total 201-202 units.

Linear Algebra

One of the following three courses:

21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	10
21-242	Matrix Theory	10

Note: 21-241 and 21-242 are intended only for students with a very strong mathematical background.

II. Foundations 18-27 units

2. Economics Foundations 9 units

73-100 Principles of Economics 9

3. Statistical Foundations 9-18 units

Sequence 1 (For students beginning their freshman or sophomore year)

36-201 Statistical Reasoning and Practice 9

and one of the following:

36-202	Statistical Methods	9
36-208	Regression Analysis	9
36-309	Experimental Design for Behavioral and Social Sciences	9

Or extra statistical elective**

*Acceptable equivalents for 36-201 are 36-207 (70-207), 36-220 and 36-247.

**Students who enter the program with 36-225/36-226 should discuss options with their advisors.

Sequence 2 (For students beginning later in their college career)

Advanced

Choose one of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9

36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9

III. Disciplinary Core 126 units

1. Economics Core 36 units

73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
73-270	Writing for Economists	9
73-374	Econometrics II	9

2. Statistics Core 36 units

36-225	Introduction to Probability Theory ^{*#}	9
and <u>one</u> of the following two courses:		
36-226	Introduction to Statistical Inference [*]	9
36-326	Mathematical Statistics (Honors) [*]	9

and both of the following two courses:

36-401	Modern Regression [*]	9
36-402	Advanced Methods for Data Analysis	9

*In order to be a major in good standing, a grade of C or better is required in 36-225 (or equivalents), 36-226 or 36-326 and 36-401. Otherwise you will not be allowed to continue in the major.

#It is possible to substitute 36-217 or 21-325 for 36-225. (36-225 is the standard introduction to probability, 36-217 is tailored for engineers and computer scientists, and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.)

3. Computing 9 units

36-350	Statistical Computing [*]	9
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*A higher level Computer Science course approved by your Academic Advisor may be used as a substitute.

4. Advanced Electives 45 units

Students must take three advanced Economics elective courses (numbered 73-300 through 73-495, excluding 73-374, 73-407 and 73-450) and two advanced Statistics elective courses (numbered 36-303, 36-315, or 36-410 through 36-495).

Total number of units for the major 182-192 units

Total number of units for the degree 360 units

Sample Program

The following sample program illustrates one way to satisfy the requirements of the Economics and Statistics Major. Keep in mind that the program is flexible and can support other possible schedules (see footnotes below the schedule).

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	36-202 Statistical Methods	21-122 Integration and Approximation **	21-240 Matrix Algebra with Applications
36-201 Statistical Reasoning and Practice	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference
73-100 Principles of Economics	73-155 Legonomics: Building Blocks of Economic Analysis	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
-----*	-----	-----	-----
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Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-402 Advanced Methods for Data Analysis	Statistics Elective	Economics Elective
36-401 Modern Regression	73-270 Writing for Economists	Economics Elective	Statistics Elective
73-374 Econometrics II	Economics Elective	-----	-----
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*In each semester, ----- represents other courses (not related to the major) which are needed in order to complete the 360 units that the degree requires.

** Students can also take 21-127 or 21-257. Students should consult with their advisor.

73-155 is not required but it is recommended by the Economics department.

Prospective PhD students might add 21-127 fall of sophomore year, replace 21-240 with 21-241, add 21-260 in spring of junior year and 21-355 in fall of senior year.

Students who elect Economics and Statistics as a second major must fulfill all Economic and Statistics degree requirements. Majors in many other programs would naturally complement a Statistics Major, including Business Administration, Social and Decision Sciences, Policy and Management, Social & Political History, and Psychology.

With respect to double-counting courses, it is departmental policy that students must have at least six courses (three Economics and three Statistics) that do not count for their primary major. If students do not have at least six, they typically take additional advanced electives.

Students are advised to begin planning their curriculum (with appropriate advisors) as soon as possible. This is particularly true if the other major has a complex set of requirements and prerequisites.

Supplemental Programs

Honors Program in Economics

Outstanding students are eligible for the honors programs in both the Tepper School of Business and the Dietrich College of Humanities and Social Sciences. For more information, consult the Dietrich Honors Program website (<http://www.cmu.edu/dietrich/undergraduate/programs/shp>).

The Tepper Senior Honors Program in Economics (<http://tepper.cmu.edu/prospective-students/undergraduate/economics/curriculum/research/senior-honors-program>) provides qualified students with the opportunity to engage in original research during their senior year at Carnegie Mellon. The primary rewards of participating in the Honors Program in Economics are three-fold. First comes the satisfaction of undertaking and completing an original piece of research. Working independently or with a faculty member to identify a research question and claim ownership of its discovery process is a rewarding experience. Second is the opportunity to challenge oneself intellectually. The third advantage is the opportunity to graduate with Tepper Honors. For many, this process of intellectual inquiry and knowledge creation is the highlight and culmination of their undergraduate academic experience.

Students are invited into the Tepper Senior Honors Program in Economics during their junior year. Invitation is based on academic achievement at Carnegie Mellon University, ability to work independently, and tenacity of spirit.

Accelerated Master's Degree Programs

Accelerated Master's Degree programs enable exceptional students to earn both an undergraduate degree and a masters degree by remaining one additional year at Carnegie Mellon. The Heinz College of Public Policy and Management offers four professional accelerated masters degree programs: a Master of Science in Arts Administration (<http://www.heinz.cmu.edu/school-of-public-policy-management/arts-management-mam>), Master of Science of Health Care and Policy Management (<http://www.heinz.cmu.edu/school-of-public-policy-management/healthcare-policy-management-hcpm>), Master of Information Systems Management (<http://www.heinz.cmu.edu/school-of-information-systems-and-management/information-systems-management-mism>), and Master of Science in Public Policy and Management (<http://www.heinz.cmu.edu/school-of-public-policy-management/public-policy-management-msppm>). The Tepper School of

Business offers one accelerated professional degree, a Master in Business Administration.

Dual Degree in Economics

A student pursuing a primary degree outside of the department may obtain a dual degree by completing all of the requirements for the B.S. in Economics or the B.S. in Economics and Statistics along with the Dietrich College general education requirements. In addition, the student's total units completed must be at least 90 units in excess of the requirement for the student's other degree(s) or at least 450 units, whichever is greater. Interested students should meet with an economics advisor.

Additional Major in Economics Curriculum

All university students are eligible to pursue an additional major in economics in conjunction with a major in any department in the university other than economics. The requirements for the Additional Major in Economics are the same as those for the B.S. in Economics, except that the Dietrich College General Education requirements are waived. In order to avoid "double counting" issues, students are encouraged to meet with an economics advisor. When courses are shared across degrees, students pursuing an Additional Major in Economics are asked to take additional advanced economics electives.

Additional Major in Economics and Statistics Curriculum

All university students are eligible to pursue a major in economics and statistics in conjunction with a major in any department in the university other than statistics or economics. The requirements for the Additional Major in Economics in Statistics are the same as those for the B.S. in Economics and Statistics, except that the Dietrich College General Education requirements are waived. In order to avoid "double counting" issues, students are encouraged to meet with an economics or statistics advisor. When courses are shared across degrees, students pursuing an Additional Major in Economics and Statistics are asked to take additional advanced economics or statistics electives.

Minor in Economics

The Minor in Economics degree program provides students with a solid understanding of economic theory and data analysis.

All university students are eligible to pursue the Minor in Economics in conjunction with a major in any other department in the university. In order to avoid "double counting" issues, students are encouraged to meet with an economics advisor. When courses are shared across degrees, students pursuing a minor in Economics are asked to take additional advanced economics electives.

All economics course counting towards the minor must be completed with a grade of "C" or higher.

Minor in Economics (Total Number of Units for the Minor: 82/91)

Mathematics Requirements (19 Units)

	Units
21-120 Differential and Integral Calculus	10
21-256 Multivariate Analysis	9

Economic Theory Requirements (18/27 Units)

	Units
73-100 Principles of Economics	9
73-230 Intermediate Microeconomics	9
73-240 Intermediate Macroeconomics *	9

*Some students may choose to focus their minor in microeconomics theory and applications. These student may elect not to take 73-240 Intermediate Macroeconomics, and instead, replace it with an additional advanced economics elective.

Quantitative Analysis Requirements (18/27 Units)

The quantitative analysis path is often determined by the major requirements. The sequence is designed to give students an understanding of probability theory, regression analysis, and quantitative economic analysis. Students are encouraged to talk with an economics advisor to determine which requirements best complement their primary fields of study.

Option One	Units
36-201 Statistical Reasoning and Practice	9
36-202 Statistical Methods	9
or 36-309 Experimental Design for Behavioral and Social Sciences	
73-407 Fundamentals of Statistical Modeling	9
Option Two	
70/36-207 Probability and Statistics for Business Applications	9
70/36-208 Regression Analysis	9
73-407 Fundamentals of Statistical Modeling	9
Option Three	
36-220 Engineering Statistics and Quality Control	9
73-407 Fundamentals of Statistical Modeling	9
Option Four	
36-217 Probability Theory and Random Processes	9
or 36-225 Introduction to Probability Theory	
36-202 Statistical Methods	9
or 36-309 Experimental Design for Behavioral and Social Sciences	
or 36-226 Introduction to Statistical Inference	
73-407 Fundamentals of Statistical Modeling	9
or 73-374 Econometrics II	

Advanced Economics Electives (18/27 Units)

Students must take two advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-374 Econometrics II, 73-407 Fundamentals of Statistical Modeling, and 73-450 Economics Colloquium) as well as courses designated by the program offered by other departments/programs. Additionally, students may work with their economics advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

Academic Standards and Policies

Undergraduate economics students are in the unique position of belonging to two CMU colleges, Marianna Brown Dietrich College of Humanities and Social Sciences and the Tepper School of Business. To find a detailed description of policies governing economics students, please consult the undergraduate section of MyTepper (<http://mytepper.tepper.cmu.edu>).

Faculty

LAURENCE ALES, Assistant Professor of Economics - Ph.D., University of Minnesota; Carnegie Mellon, 2008-.

KATHARINE ANDERSON, Assistant Professor of Economics and Entrepreneurship - Ph.D., University of Michigan; Carnegie Mellon, 2010-.

STEPHEN M. CALABRESE, Visiting Associate Professor of Economics, Carnegie Mellon University-Qatar - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007-.

KAREN B. CLAY, Associate Professor of Economics and Public Policy, H. J. Heinz III College - Ph.D., Stanford University; Carnegie Mellon, 1998-.

ROBERT M. DAMMON, Dean, Education; Professor of Financial Economics - Ph.D., University of Wisconsin; Carnegie Mellon, 1984-.

TIMOTHY P. DERDINGER, Assistant Professor of Economics and Strategy - Ph.D., University of Southern California; Carnegie Mellon, 2009-.

KENNETH B. DUNN, Professor of Financial Economics - Ph.D., Purdue University; Carnegie Mellon, 1979-.

DENNIS N. EPPLÉ, Thomas Lord University Professor of Economics; Head, Economics Programs - Ph.D., Princeton University; Carnegie Mellon, 1974-.

MARIA MARTA FERREYRA, Associate Professor of Economics – Ph.D., University of Wisconsin; Carnegie Mellon, 2002–.

CHRISTINA FONG, Senior Research Scientist in Social and Decision Sciences, Dietrich College of Humanities and Social Sciences – Ph.D., University of Massachusetts; Carnegie Mellon, 2001–.

MARTIN GAYNOR, E.J. Barone Professor of Economics and Health Policy, H. J. Heinz III College – Ph.D., Northwestern University; Carnegie Mellon, 1995–.

MARVIN GOODFRIEND, Friends of Allan Meltzer Professorship; Professor of Economics – Ph.D., Brown University; Carnegie Mellon, 2005–.

RICHARD C. GREEN, Senior Associate Dean, Faculty and Research; Richard M. and Margaret S. Cyert Chair; Professor of Financial Economics – Ph.D., University of Wisconsin; Carnegie Mellon, 1982–.

JOACHIM RYOHEI GROEGER, Assistant Professor of Economics – Ph.D., London School of Economics; Carnegie Mellon, 2010–.

ISA E. HAFALIR, Associate Professor of Economics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2007–.

BURTON HOLLIFIELD, PNC Professor of Finance; Professor of Financial Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1999–.

KARAM KANG, Assistant Professor of Economics – Ph.D., University of Pennsylvania; Carnegie Mellon, 2012–.

ONUR KESTEN, Associate Professor of Economics – Ph.D., University of Rochester; Carnegie Mellon, 2005–.

YAROSLAV KRYUKOV, Assistant Professor of Economics – Ph.D., Northwestern University; Carnegie Mellon, 2008–.

FINN KYDLAND, The Richard P. Simons Distinguished Professorship; University Professor of Economics; Nobel Laureate (2004) – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1977–.

REBECCA LESSEM, Assistant Professor of Economics – Ph.D., University of Wisconsin-Madison; Carnegie Mellon, 2011–.

BENNETT T. MCCALLUM, H. J. Heinz Professor of Economics – Ph.D., Rice University; Carnegie Mellon, 1981–.

ALLAN H. MELTZER, The Allan H. Meltzer University Professor of Political Economy – Ph.D., University of California, Los Angeles; Carnegie Mellon, 1957–.

ROBERT A. MILLER, Richard M. Cyert and Morris DeGroot Professor of Economics and Statistics – Ph.D., University of Chicago; Carnegie Mellon, 1982–.

CHRISTOPH MUELLER, Assistant Professor of Economics – Ph.D., University of Michigan; Carnegie Mellon, 2010–.

JOHN R. O'BRIEN, Associate Professor of Accounting and Experimental Economics – Ph.D., University of Minnesota; Carnegie Mellon, 1984–.

NICOLAS PETROSKY-NADEAU, Assistant Professor of Economics – Ph.D., University of Quebec; Carnegie Mellon, 2009–.

DUANE J. SEPPI, BNY Mellon Professor of Finance; Head, Master of Science in Computational Finance – Ph.D., University of Chicago; Carnegie Mellon, 1986–.

PATRICK W. SILEO, Associate Dean, Carnegie Mellon University-Qatar; Associate Teaching Professor of Economics and Finance, Carnegie Mellon University-Qatar – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1999–.

CHRISTOPHER SLEET, Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2005–.

FALLAW B. SOWELL, Associate Professor of Economics – Ph.D., Duke University; Carnegie Mellon, 1988–.

CHESTER S. SPATT, Pamela R. and Kenneth B. Dunn Professor of Finance – Ph.D., University of Pennsylvania; Carnegie Mellon, 1979–.

STEPHEN E. SPEAR, Professor of Economics – Ph.D., University of Pennsylvania; Carnegie Mellon, 1982–.

CHRISTOPHER I. TELMER, Associate Professor of Financial Economics – Ph.D., Queen's University (Canada); Carnegie Mellon, 1992–.

SEVIN YELTEKIN, Associate Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2005–.

M. BUMIN YENMEZ, Assistant Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2010–.

ARIEL ZETLIN-JONES, Assistant Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2012–.

Visiting Faculty

SERRA BORANBAY-AKAN, Visiting Assistant Professor of Economics – Ph.D., Northwestern University; Carnegie Mellon, 2013–.

BILLIE MORROW DAVIS, Post-Doctoral Fellow, Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2013–.

Adjunct Faculty

CAROL B. GOLDBURG, Executive Director, Undergraduate Economics Program; Adjunct Professor of Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2005–.

ELIF INCEKARA HAFALIR, Adjunct Assistant Professor of Economics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2007–.

FREDERICK H. RUETER, Adjunct Professor of Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1998–.

C. SCOTT WYATT, Adjunct Professor of Business Communications – Ph.D., University of Minnesota, Twin Cities; Carnegie Mellon, 2013–.

BENJAMIN ZAMZOW, Adjunct Professor – Ph.D., University of Arizona; Carnegie Mellon, 2013–.

Carnegie Mellon University in Qatar

Iker Baybars, Dean of Carnegie Mellon University in Qatar
 Selma Limam Mansar, Associate Dean for Education
 Undergraduate Office: CMB 1098
<http://www.qatar.cmu.edu/>

Carnegie Mellon University in Qatar is Carnegie Mellon's first and only undergraduate branch campus. We opened in 2004 as part of a collaborative effort with the Qatar Foundation to bring outstanding American educational programs to the Middle East.

Degree Offerings

Carnegie Mellon University in Qatar offers five academic programs: Biological Sciences (p. 317), Business Administration (p. 374), Computer Science (p. 353), Computational Biology (p. 77), and Information Systems (p. 250). To examine the requirements for those degrees, see their respective main campus college sections elsewhere in the Undergraduate Catalog. The purpose of this section is to describe the CMU-Q policies that are independent from those of the Pittsburgh campus and outline procedures that are common to students in all programs in Qatar.

Major Sample Schedules

Sample schedules for how CMU-Q students nominally track through the academic programs can be found on the CMU-Q website as follows:

- Biological Sciences (<http://www.qatar.cmu.edu/curriculum-bs>)
- Business Administration (<http://www.qatar.cmu.edu/curriculum-ba>)
- Computer Science (<http://www.qatar.cmu.edu/curriculum-cs>)
- Computational Biology (<http://www.qatar.cmu.edu/the-curriculum>)
- Information Systems (<http://www.qatar.cmu.edu/the-curriculum>)

Business Administration Tracks and Advisors

The Business Administration program requires its students to fulfill the requirements of a track (a sequence of courses in a particular discipline). The following tracks are offered at Carnegie Mellon University in Qatar:

- Entrepreneurship (advisor: Tom Emerson)
- Finance (advisor: Fuad Farooqi)
- General Management (advisor: George White)
- Manufacturing Management and Consulting (advisor: Sham Kekre)
- Marketing (advisor: Peter Stuetgen)

Information Systems Content Areas

The Information Systems program requires its students to complete a minimum of 27 units of a content area. For advice on specific requirements, contact Daniel Phelps. The following content areas are offered at Carnegie Mellon University in Qatar:

- Computing and Information Systems & Technology
- Social and Global Systems
- User-Centered Information Design
- Applied Informatics

Minors

In addition to the major degree programs, Carnegie Mellon also offers a number of minors. Minors typically consist of six courses that provide the student with a substantial exposure to the core of that academic discipline. As with the major programs, the requirements of these minors are set by their respective departments on the main campus:

- Architecture (advisors: TBC. Refer to Selma Limam Mansar)
- Biology (advisor: Ken Hovis)
- Business Administration (advisor: George White)
- Computational Biology (advisors: Ken Hovis, Khaled Harras)
- Computer Science (advisor: Khaled Harras)
- English Studies (advisor: Ludmila Hyman)
- Ethics (advisor: David Gray)

- Global Systems and Management (advisor: Daniel Phelps)
- History (advisor: Ben Reilly)
- Information Systems (<http://www.qatar.cmu.edu/information-systems>) (advisor: Daniel Phelps) [only offered in Qatar]
- Mathematical Sciences (advisor: Hasan Demirkoparan)
- Professional Writing (advisor: Susan Hagan)
- Psychology (advisor: Crista Crittenden)

Academic Standards and Actions

Academic Standards

Carnegie Mellon University in Qatar complies with common University policies unless otherwise noted. The curriculum requirements for the Biological Sciences, Business Administration, Computer Science, Computational Biology, and Information Systems majors are set by the respective departments of the Mellon College of Science, Tepper School of Business, the School of Computer Science, and the Dietrich College of Humanities and Social Sciences on the main campus. The same academic standards, policies, and actions apply to all programs at CMU-Q as at the Pittsburgh campus.

Graduation Requirements

Residency

Candidate for a Bachelor's degree must complete a minimum of four semesters of full-time study, or the equivalent of part-time study, comprising at least 180 units of coursework at Carnegie Mellon.

Cumulative QPA

To be eligible to graduate, undergraduate students must complete all course requirements for their program with a cumulative Quality Point Average of at least 2.0 for all courses taken. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. Some programs may have additional QPA requirements in order to graduate. Students are encouraged to confirm all graduation requirements with their academic advisor.

University Honors

Students maintaining a cumulative QPA of at least 3.5 after seven semesters of full-time enrollment or raising their QPA to 3.5 upon completing their graduation requirements in their final semester will graduate with University Honors.

Academic Actions

Students carrying either a full-time course load (defined as 36 or more units) or a part-time course load (defined as fewer than 36 units) are subject to academic actions.

Dean's List

Students earn Dean's List recognition in a given semester by achieving one of two minimum standards. They must either earn a semester QPA of 3.75 or higher (while taking at least 36 factorable units and receiving no incomplete grades) or earn a semester QPA of 3.50 or higher (while taking at least 45 factorable units and receiving no incomplete grades). The CMU-Q Dean's List is calculated uniformly for all students across all majors due to the fact that CMU-Q majors are drawn from four different Pittsburgh colleges with varying Dean's List criteria.

Other Academic Actions

Students are subject to academic actions if they fail to meet the minimum standards toward their degree.

Minimum Standards

The minimum standards are defined as follows:

- First year students: a semester QPA of at least 1.75.
- Beyond the first year: a semester QPA or the cumulative QPA (excluding the first year) of at least 2.0.
- Students who begin a semester enrolled in 36 or more factorable units and later drop below 36 units are subject to academic actions regardless of their semester QPA.

Probation

Probation occurs when a student's semester record fails to meet the minimum standards described above. The term of a probation is one semester as a full-time student. Students are removed from probation if they complete at least 36 factorable units and:

- For a first year student, probation is removed at the end of the second semester if the second semester's QPA is 1.75 or above.
- For students in the third or above semesters, probation is removed if they raise their cumulative QPA above 2.00.

Probation Continued

The school may continue a student's probation if the student's cumulative record does not meet minimum standards, but his or her semester record suggests that the student may do so by the end of the next semester. This action is normally taken only when a student's semester QPA is above 2.0 but their cumulative QPA is not yet above 2.0.

Suspension

A student who fails to meet the minimum standards described above at the end of the probation semester will be suspended.

- A first-year student will be suspended if the QPA from each semester is below 1.75.
- A student in the third or subsequent semester of study will be suspended if the semester factor or the cumulative factor (excluding the first year) is below 2.00 for two consecutive semesters.

Suspension is for a minimum of one year and the student is required to follow University procedures for departing from campus. At the end of the year, the student may petition to return to CMU-Q by:

- Receiving permission in writing from the Associate Dean for Education to resume their studies. This permission would normally be granted after the student would produce evidence for fulfilling return conditions (if any) and for taking convincing steps to ameliorate the cause of the suspension. To get approval to resume their studies, the student must demonstrate that they are better prepared to perform above the minimum standards for graduation than before they were suspended.
- Completing a Return from Leave of Absence Form from Enrollment Services.

Students coming back from suspension are placed on Probation for the semester of their return.

Students who have been suspended or have withdrawn are required to absent themselves from the campus within a maximum of two days after the action and to remain off the campus for the duration of the time specified. This action includes debarment from part-time or summer courses at the university for the duration of the period of the action. Suspended students may not hold student jobs with the university.

Drop

A student who fails to meet minimum standards at any point after returning from a suspension is subject to a drop action. A drop action is a permanent severance; the student is required to follow University procedures for departing from campus and may not enroll again in the future.

The typical progression of academic actions is Probation, Suspension, then Drop but the intent of the academic actions are to take measures that are in the student's best interest, and therefore the school may bypass one or more of these steps in an unusual case and suspend or drop a student without prior probation.

Other Regulations Affecting Student Status

Adding a Class

Students may add classes to their schedule under the following rules:

1. Students may add a full-semester course through the first 10 class days of the semester.
2. Students may add half-semester (mini) courses through the first 5 class days of the course.

Dropping/Withdrawing from a Class

Students who wish to drop a course (without receiving a "W" grade on the transcript) must do so before the published CMU-Q Drop deadline (shortly after mid-semester grades are published). After that date, students may withdraw from a course up to the last day of classes and receive a "W" grade on their transcript. After the last day of classes student may not withdraw from a class. All drops/withdrawals must be consistent with remaining a full-time student, that is, a student carrying a full-time course load (at least 36 units) as of the last day to add (the 10th class day of the semester) may not drop/withdraw below 36 units after that time.

Course Overloads

A normal maximum load for a CMU-Q student is 51 units. In order to overload (i.e., take more than 51 units but no more than 63), a student must have attained a QPA of at least 3.0 in the previous semester, or have a cumulative QPA of 3.0. A student wishing to pursue a greater number of units must petition the Associate Dean for Education to do so.

Non-Carnegie Mellon Courses

Carnegie Mellon University offers students the opportunity to take courses for credit through a cross-registration program and through the receipt of transfer credit from other accredited institutions. The Carnegie Mellon transcript will include information on such courses as follows:

Carnegie Mellon courses and courses taken through the university's cross-registration program will have grades recorded on the transcript and be factored into the QPA. All other courses will be recorded on this transcript indicating where the course was taken, but no grade will be reported. Such courses will not be taken into account for academic actions, honors or QPA calculations. (Note: Suspended students may take courses elsewhere with prior approval; however, they will not receive transfer credit.)

Cross Registration

Courses offered for cross-registration are those taken through an agreement with Texas A&M University at Qatar; Georgetown School of Foreign Service in Qatar; Northwestern University in Qatar; Virginia Commonwealth University in Qatar; and Weill Cornell Medical College in Qatar that full-time students at Carnegie Mellon University in Qatar can take up to one class a semester at their schools. Cross-registration requires the completion of a cross-registration form with the appropriate signatures from the home and host institutions. Completion of the form does not guarantee a space in the requested course. The agreement only applies during the regular academic year, normal course transfer rules apply in the summer.

Course Transfer

Students may receive credit for courses taken outside of Carnegie Mellon if they successfully petition the Associate Dean for Education in advance for permission. Students must take these courses for a letter grade and instruction must be in English for non-language courses. Credit (but not the grade) will normally transfer for courses with a grade equivalent to at least a "B". The class's course description must be a close match to the Carnegie Mellon course and from an accredited institution. Students may not receive credit for any courses taken on-line unless there is some safeguard to ensure that the actual student took the course (e.g., a proctored final taken under supervision at CMU-Q).

Students may not receive credit for more than five non-CMU courses during their undergraduate career as a Carnegie Mellon student. Classes taken prior to enrolling in Carnegie Mellon, during study abroad semesters, and as cross registration with other education City schools do not count toward the course transfer limit. All students must meet the University's residency requirement of completing at least 180 units of Carnegie Mellon coursework.

Campus Exchange and Transfer

Campus Exchange

CMU-Q and Pittsburgh students in good academic standing (not on Probation/Suspension) may study on the other campus for one semester on a space available basis and with the approval of both the home and host departments. Space constraints on both campuses may force programs to limit the number of students who can exchange in any given semester.

CMU-Q students may study abroad for a second semester at another institution (not CMU Pittsburgh) if an appropriate additional study abroad opportunity arises and their academic advisor agrees.

Summer studies in Pittsburgh are not subject to any constraint other than being in good academic standing (not on Probation/Suspension).

Transfer

Internally between majors at CMU-Q

Students may transfer between majors at CMU-Q on a space-available and academic performance basis. Students interested in transferring should consult with the Associate Dean for Education and the academic advisor of the new major. First-year students may not apply for transfer until they receive their spring mid-semester grades.

Between CMU-Q and Carnegie Mellon, Pittsburgh

Most majors in Pittsburgh have very few open spaces for transfer students. As a result, decisions about transfer to any major in Pittsburgh will be made by the receiving department, are highly competitive, and are not likely. It has historically been very difficult to be granted transfer to Pittsburgh.

Transfers to CMU-Q from other Universities

Transfer students from other universities must apply through the Admissions Office at Carnegie Mellon University in Qatar. The Admissions Office, the Associate Dean for Education, and the program director will determine if there is space available in the desired program and if the student's past academic performance warrants admission.

Faculty

SNEJANA ABARJI, Visiting Associate Professor – Ph.D., Landau Institute for Theoretical Physics; Carnegie Mellon, 2013–.

AMAL AL-MALKI, Associate Teaching Professor – Ph.D., University of London; Carnegie Mellon, 2004–.

CHADI AOUN, Associate Teaching Professor – Ph.D., University of New South Wales; Carnegie Mellon, 2014–.

MOHAMED BOUAOUINA, Assistant Teaching Professor – Ph.D., Pierre and Marie Curie University; Carnegie Mellon, 2013–.

ILKER BAYBARS, Professor and Dean; Deputy Dean Emeritus, Tepper School of Business; George Leland Bach Chair – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1979–.

STEPHEN CALABRESE, Visiting Associate Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–.

ILIANO CERVESATO, Teaching Professor – Ph.D., University of Torino; Carnegie Mellon, 2006–.

ANIS CHARFI, Associate Teaching Professor – Ph.D., Technische Universität Darmstadt; Carnegie Mellon, 2015–.

ALEXANDER CHEEK, Assistant Teaching Professor – Master of Design, Carnegie Mellon University; Carnegie Mellon, 2014–.

BENJAMIN COLLIER, Visiting Assistant Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2012–.

CRISTA CRITTENDEN, Visiting Assistant Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2014–.

HASAN DEMIRKOPARAN, Associate Teaching Professor – Ph.D., Michigan State University; Carnegie Mellon, 2005–.

THOMAS EMERSON, David T. and Lindsay J. Morgenthaler Distinguished Career Professor of Entrepreneurship – Ph.D., Rice University; Carnegie Mellon, 2000–.

MUHAMMAD FUAD FAROOQI, Visiting Assistant Professor – Ph.D., Richard Ivey School of Business; Carnegie Mellon, 2013–.

DAVIDE FOSSATI, Assistant Teaching Professor – Ph.D., University of Illinois-Chicago; Carnegie Mellon, 2010–.

JOHN GASPER, Visiting Assistant Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2010–.

DAVID GRAY, Assistant Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2009–.

SUSAN HAGAN, Assistant Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2004–.

MAHER HAKIM, Associate Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2012–.

MOHAMMAD HAMMOUD, Visiting Assistant Professor – Ph.D., University of Pittsburgh; Carnegie Mellon, 2014–.

KHALED HARRAS, Associate Teaching Professor – Ph.D., University of California-Santa Barbara; Carnegie Mellon, 2007–.

ERIK HELIN, Special Lecturer – M.A., Eastern Michigan University; Carnegie Mellon, 2006–.

AMAL HELU, Visiting Associate Professor – Ph.D., Old Dominion University; Carnegie Mellon, 2014–.

ADAM HODGES, Visiting Assistant Professor – Ph.D., University of Colorado, Boulder; Carnegie Mellon, 2014–.

KEN HOVIS, Assistant Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2011–.

STARLING HUNTER, Visiting Associate Teaching Professor – Ph.D., Duke University; Carnegie Mellon, 2007–.

LUDMILA HYMAN, Assistant Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2010–.

ZEINAB IBRAHIM, Teaching Professor – Ph.D., Georgetown University; Carnegie Mellon, 2009–.

VALENTIN ILYIN, Associate Teaching Professor – Ph.D., Shubnikov Institute of Crystallography; Carnegie Mellon, 2012–.

LANSINE KABA, Distinguished Visiting Professor – Ph.D., Northwestern University; Carnegie Mellon, 2009–.

CHRISTOS KAPOUTSIS, Assistant Teaching Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2012–.

SHAM KEKRE, Distinguished Career Professor – Ph.D., University of Rochester; Carnegie Mellon, 2006–.

ONUR KESTEN, Associate Professor – Ph.D., University of Rochester; Carnegie Mellon, 2006–.

NIRAJ KHARE, Visiting Assistant Professor – Ph.D., Ohio State University; Carnegie Mellon, 2014–.

FINN KYDLAND, Richard P. Simmons Distinguished Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1977–.

DIVAKARAN LIGINLAL, Teaching Professor – Ph.D., University of Arizona-Tucson; Carnegie Mellon, 2009–.

TERESA MACGREGOR, Director of Library – MSLS, University of Kentucky; Carnegie Mellon, 2012–.

SELMA LIMAM MANSAR, Teaching Professor and Associate Dean for Education – Ph.D., National Polytechnic Institute of Grenoble; Carnegie Mellon, 2007–.

J. PATRICK MCGINNIS, Assistant Teaching Professor – M.A., Pittsburg State University; Carnegie Mellon, 1999–.

THOMAS MITCHELL, Assistant Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2013–.

TRIDAS MUKHOPADHYAY, Deloitte Consulting Professor of e-Business – Ph.D., University of Michigan; Carnegie Mellon, 1986–.

TERRANCE MURPHY, Teaching Professor – Ph.D., University of Washington; Carnegie Mellon, 2008–.

JOHN O'BRIEN, Associate Professor and Associate Dean – Ph.D., University of Minnesota; Carnegie Mellon, 1984–.

KEMAL OFLAZER, Teaching Professor and Associate Dean for Research – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2008–.

MARION OLIVER, Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2004–.

SILVIA PESSOA, Associate Teaching Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2006–.

DANIEL PHELPS, Associate Teaching Professor – Ph.D., Florida State University; Carnegie Mellon, 2007–.

SAQUIB RAZAK, Assistant Teaching Professor – Ph.D., SUNY-Binghamton; Carnegie Mellon, 2008–.

BENJAMIN REILLY, Associate Teaching Professor – Ph.D., University of Pittsburgh; Carnegie Mellon, 2004–.

DUDLEY REYNOLDS, Teaching Professor – Ph.D., Indiana University-Bloomington; Carnegie Mellon, 2007–.

GORDON RULE, Professor – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1996–.

ALICIA SALAZ, Reference and Instruction Librarian – MLIS, University of Washington; Carnegie Mellon, 2013–.

THIERRY SANS, Assistant Teaching Professor - Ph.D., ENST-Bretagne; Carnegie Mellon, 2007-.

PETER STUETTGEN, Visiting Assistant Professor - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2012-.

RAY TSAI, Professor of Practice - Ph.D., University of North Texas; Carnegie Mellon, 2011-.

STEPHEN VARGO, Assistant Teaching Professor - MBA, Carnegie Mellon University; Carnegie Mellon, 1997-.

ANNETTE SHOBA VINCENT, Assistant Teaching Professor - Ph.D., National University of Singapore; Carnegie Mellon, 2012-.

GEORGE WHITE, Distinguished Career Professor - Ph.D., University of Oregon; Carnegie Mellon, 2007-.

ZELEALEM YILMA, Visiting Assistant Professor - Ph.D., Carnegie Mellon University; Carnegie Mellon, 2014-.

IHAB YOUNIS, Faculty - Ph.D., Ohio State University; Carnegie Mellon, 2015-.

Descriptions

Aerospace Studies-ROTC Courses

31-101 Foundations of the United States Air Force

Fall: 3 units

AS100 is a survey course designed to introduce cadets to the United States Air Force and Air Force Reserve Officer Training Corps. Featured topics include: mission and organization of the Air Force, officership and professionalism, military customs and courtesies, Air Force officer opportunities, and an introduction to communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.

31-102 Foundations of the United States Air Force

Spring: 3 units

AS100 is a survey course designed to introduce cadets to the United States Air Force and Air Force Reserve Officer Training Corps. Featured topics include: mission and organization of the Air Force, officership and professionalism, military customs and courtesies, Air Force officer opportunities, and an introduction to communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.

31-105 Air Force Leadership Laboratory

All Semesters

The AS100 and AS200 Leadership Laboratory courses (LLABs) include a study of Air Force customs and courtesies, drill and ceremonies, and military commands. The LLAB also includes studying the environment of an Air Force officer and learning about areas of opportunity available to commissioned officers. The AS300 and AS400 LLABs consist of activities classified as leadership and management experiences. They involve the planning and controlling of military activities of the cadet corps, and the preparation and presentation of briefings and other oral and written communications. LLABs also include interviews, guidance, and information, which will increase the understanding, motivation, and performance of other cadets.

31-106 Air Force Leadership Laboratory

All Semesters

The AS100 and AS200 Leadership Laboratory courses (LLABs) include a study of Air Force customs and courtesies, drill and ceremonies, and military commands. The LLAB also includes studying the environment of an Air Force officer and learning about areas of opportunity available to commissioned officers. The AS300 and AS400 LLABs consist of activities classified as leadership and management experiences. They involve the planning and controlling of military activities of the cadet corps, and the preparation and presentation of briefings and other oral and written communications. LLABs also include interviews, guidance, and information, which will increase the understanding, motivation, and performance of other cadets.

31-107 Air Force Leadership Laboratory

All Semesters

The AS100 and AS200 Leadership Laboratory courses (LLABs) include a study of Air Force customs and courtesies, drill and ceremonies, and military commands. The LLAB also includes studying the environment of an Air Force officer and learning about areas of opportunity available to commissioned officers. The AS300 and AS400 LLABs consist of activities classified as leadership and management experiences. They involve the planning and controlling of military activities of the cadet corps, and the preparation and presentation of briefings and other oral and written communications. LLABs also include interviews, guidance, and information, which will increase the understanding, motivation, and performance of other cadets.

31-108 Air Force Leadership Laboratory

All Semesters

The AS100 and AS200 Leadership Laboratory courses (LLABs) include a study of Air Force customs and courtesies, drill and ceremonies, and military commands. The LLAB also includes studying the environment of an Air Force officer and learning about areas of opportunity available to commissioned officers. The AS300 and AS400 LLABs consist of activities classified as leadership and management experiences. They involve the planning and controlling of military activities of the cadet corps, and the preparation and presentation of briefings and other oral and written communications. LLABs also include interviews, guidance, and information, which will increase the understanding, motivation, and performance of other cadets.

31-201 The Evolution of Air and Space Power

Fall: 3 units

The AS200 course designed to examine general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the Persian Gulf War. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today's USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g. Principles of War and Tenets of Air and Space Power. As a whole, this course provides the cadets with a knowledge level understanding for the general element and employment of air and space power, from an institutional doctrinal and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values with the use of operational examples and historical Air Force leaders and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.

31-202 The Evolution of Air and Space Power

Spring: 3 units

The AS200 course designed to examine general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the Persian Gulf War. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today's USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g. Principles of War and Tenets of Air and Space Power. As a whole, this course provides the cadets with a knowledge level understanding for the general element and employment of air and space power, from an institutional doctrinal and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values with the use of operational examples and historical Air Force leaders and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.

31-301 Air Force Leadership Studies

Fall: 9 units

AS300 is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts being studied. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences in officer-type activities, giving students the opportunity to apply the leadership and management principles of this course.

31-302 Air Force Leadership Studies

Spring: 9 units

AS300 is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts being studied. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences in officer-type activities, giving students the opportunity to apply the leadership and management principles of this course.

31-401 National Security Affairs and Preparation for Active Duty

Fall: 9 units

AS400 examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officership, military justice, civilian control of the military, preparation for active duty, and current issues affecting military professionalism. Within this structure, continued emphasis is given to refining communication skills. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences, giving students the opportunity to apply the leadership and management principles of this course.

31-402 National Security Affairs and Preparation for Active Duty

Spring: 9 units

AS400 examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officership, military justice, civilian control of the military, preparation for active duty, and current issues affecting military professionalism. Within this structure, continued emphasis is given to refining communication skills. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences, giving students the opportunity to apply the leadership and management principles of this course.

Architecture Courses

48-025 First Year Seminar: Architecture Edition I

Fall: 3 units

In this course, students will learn about effective strategies for teaching architecture and the built environment. Topics include the cognitive differences between novices and experts, instructional techniques, and goal alignment. As part of the coursework, each student will implement these teaching strategies to design and teach a lesson. Elements of developmental psychology, learning theories, and classroom practices will inform the architectural education lesson. Teaching and learning techniques can be generalized for communication with clients, practice, and the community.

48-026 First Year Seminar: Architecture Edition II

Spring: 3 units

The first year seminar (part 2) introduces students to opportunities at Carnegie Mellon University and beyond. The goal of this course is to encourage students to pursue their interests inside and outside of the School of Architecture by introducing a range of opportunities, including study abroad experiences, internships, academic minors/additional majors, and graduate study. The introduction of the study abroad process and travel options will encourage students to consider a study away experience into their academic curriculum. Students will explore their additional academic interests by identifying their psychological preferences through the Myers-Briggs Type Indicator and matching these preferences with academic minors/additional majors at CMU. The presentation of the Intern Development Program (IDP) will engage students in considering future plans for earning IDP hours and understanding the process of securing an architectural internship. Students will be introduced to the process of developing an independent research project. Additional topical areas to be covered in the seminar will include an evaluation of the previous semester, scholarship/academic funding opportunities, graduate studies, and schedule planning for upcoming semesters.

48-065 Architectural Rapid Prototyping for Non-Architects

Intermittent: 9 units

The continuing development of rapid prototyping technologies has expanded the range of applications and their accessibility. The ubiquity of the three dimensional printer is only a matter of time: today's availability of the desktop 3D printer has made it conceivable that they will soon become as common as their two-dimensional counterparts. This course will test the current capabilities of the desktop 3D printer, and explore the ways in which it can be used to develop architectural massings and details. Through the iterative process, we will test your original designs at a number of scales, from site context to the building to the component. While there is no prerequisite for this course per se, it is expected that students understand the basic fundamentals of architectural drawing conventions (plans, sections, elevations), and/or are conversant in 3-D modeling programs (Sketchup, Revit, Rhino, etc). Preference will be given to those intending to graduate with a minor in Architecture.

48-095 Spatial Concepts for Non-Architects I

Fall and Spring

This course serves as an introduction to the spatial concepts of architecture for students from other disciplines. The course is focused entirely on project design work (this is not an historical survey, technical or lecture course). This course is very hands-on. Projects will explore the design and experience of spatial environments through a series of creative investigations. The semester will be broken in to 3 parts: Intro/Exploration and a long term project. In Intro/Exploration, students will have many hands on opportunities to start to build a common language to describe spatial investigations as well as creating them. This will consist of short projects, with each design investigation progressively building upon the previous exploration; these early projects will consist of both individual and group work. They will focus on Making. The second half of the semester will consist of one long term project to be created individually, incorporating students' personal theories of architecture based on an overarching question. Studio work will be supported by group discussion based upon critical review of student work, readings, slide presentations, videos and films. There will also be a few field trips. Students are encouraged to explore their own areas of interest with respect to their work in class. Self-motivation, class attendance and an open mind is mandatory, however, no prior architectural, engineering or artistic experience is required. Students are expected to perform work both inside and outside of class. Students should be prepared to purchase various supplies throughout the course. This course is in partial fulfillment of requirements for an Architecture Minor.

48-100 Architecture Design Studio: Foundation I

Fall: 12 units

As the first architectural design studio course, the Foundation I studio establishes a fundamental understanding of representation and abstraction to which more of your own thoughts and ideas about spatial thinking can be added. This will involve, by means of the architectural studio, a reiterative investigation into the relationship of technique, form, and meaning through study, invention, testing, and evaluation. During this semester a series of short problems will be given to expose you to the complexities of visual communication and the design act; to develop skills of spatial manipulation; to give you the self-confidence in making valid decisions within set time limits; to develop the skills of graphic presentation necessary for interpreting and communicating your architectural intentions; and above all, to instill the ability to combine insight with the rigorous analytical study in a design process that is efficient, personally effective, and which becomes second nature to you as a working process.

48-105 Architecture Design Studio: Foundation II

Spring: 12 units

The 48-105 studio, called Foundation II, is the second studio in CMU's professional B.Arch program. It builds on the lessons from 48-100 about clear architectural communication and abstract spatial-definition, but adds a greater emphasis on the material and experiential understanding of how architecture is made and used. We continue to emphasize architectural drawing and models (both analog and digital) as the primary means of architectural communication, but also as a method of creatively exploring and rigorously testing fundamental architectural ideas. We investigate, research, analyze, diagram, and apply lessons from local architecture, and great architecture of the past, in studio, and in the parallel survey of architectural history. We introduce the use of systems, computational thinking, and rules in the design process to create order, deal with a range of parameters, and satisfy specific performance criteria. Beginning with more abstract formal design exercises, and ending with the design of a small building, we explore how tectonics, joinery, materials, as well as site, orientation, context, and human use can be harnessed to inspire great design. The design process is still carefully controlled, but students are encouraged to begin to speculate and take careful risks.
Prerequisite: 48-100

48-116 Building Physics

All Semesters: 9 units

In the first part, the course will introduce fundamental lighting principles in the context of performance-based architectural design and diagnostics. The course will cover relevant aspects of lighting environment that affect the physiological and psychological experience of buildings, performance metrics, design and benchmarking methods, and contemporary simulation tools. Topics include a review of physiological and psychological response to the visual environment, analytical and numeric methods for the prediction of lighting conditions in interior spaces, lighting engineering and design methods, and application of computer-aided lighting simulation tools in architectural design. In the second part, the course will introduce fundamental thermal principles in the context of performance-based architectural design and diagnostics. The course will cover relevant aspects of thermal environment that affect the physiological and psychological experience of buildings, performance metrics, design and benchmarking methods, and contemporary simulation tools. Topics include a review of basic theory of heat transfer, thermal dynamics, thermal comfort, analytical and numeric methods for the prediction of building thermal load and energy consumption, and application of computer-aided thermal simulation tools for building thermal design. Autodesk Ecotect and Radiance software programs will be used for lighting and thermal performance simulation.

48-120 Digital Media I

Fall: 6 units

IDM is a required course for all first year architecture students. The course introduces students to a wide range of digital methods and concepts available to architects for design, representation, and documentation. The coursework is directly coordinated with Studio assignments providing the students with the opportunity to master their digital skills in a meaningful manner. Due to the amount of content covered there is no single text for this course, but the course is supported by materials created by the instructor. IDM addresses topics such as digital image editing, vector illustration, HTML coding, and 3D modeling.

48-121 Analog Media I

Fall: 6 units

Architects draw and build models for a variety of reasons: to record and reference; to analyze and reveal order, intent, and relationships; to speculate; and to visualize new propositions. The study of architecture requires the connection between the mind, the eye and the hand, so that the nature of ideas and their relationship to physical form can be investigated. The connection of the mind, hand and drawing skills requires considerable time and effort. This course introduces why architects use these forms of representation. Students are introduced to how to do basic academic research as well direct assignments that apply the fundamentals of freehand drawings and drafting techniques as it pertains to plans, sections, elevations and paraline drawing, analytical diagramming and model making.

48-125 Digital Media II

Spring: 6 units

IDM2 is a required course for all first year architecture students. This course is the continuation of IDM. IDM2 introduces students to measured drafting and the process of creating a construction drawing set. The coursework is directly coordinated with Studio assignments providing the students with the opportunity to master their digital skills in a meaningful manner. Due to the amount of content covered there is no single text for this course, but the course is supported by materials created by the instructor. IDM2 addresses topics such as digital drafting, construction drawings, advanced 3D modeling and HTML programming.

Prerequisite: 48-120

48-126 Analog Media II

Spring: 6 units

?Drawing and Appearance? is a traditional course in free-hand architectural drawing. Its central learning objective is building a capacity for visualizing three-dimensional space through the making of hand-made drawings. Two secondary objectives foster visual literacy: the ability to use line, tonal values and color to represent architectural space and the ability to use drawing to represent architectural proposals at various levels of abstraction Coursework includes free-hand and constructed perspective, shade and shadow projection, chiarroscuro drawing in colored pencil and color drawing in pastel. Work is submitted in three portfolio submissions of two weeks duration each. Coursework is built around exercises in the required course text: *Drawing and Perceiving*, John Wiley and Sons.

48-200 Architecture Design Studio: Elaboration I

Fall: 18 units

This studio is an introduction to architectural design stressing concept generation and the development of a rich design process to create evocative spatial experiences through architecture. Building on the explorations of form and space in the 1st year, we investigate in greater depth the role that program, context, and the physical "elements of architecture" play in creating meaningful architecture. We seek to understand design principles underlying the buildings of the past and present, from the broadly theoretical and conceptual, to the real implications of tectonics and sustainability, and apply these ideas with intent and significance. We will focus on developing challenging architectural ideas, profound building details, and effective ways of communicating them in order to explore architecture's potential for creating poetic expressions, appropriate shelter, or exalted experiences, as well as its ability to embody ideas and impart meaning to the world around us.

Prerequisite: 48-105

48-205 Architecture Design Studio: Elaboration II

Spring: 18 units

Building on the fall studio, the spring semester is concerned with more in-depth understanding and development of designs for small-scale buildings, now informed by greater knowledge related to materials, fabrication, and the act of construction. Following the "New Materiality" evident in architecture today, and acknowledging the importance of materials and assembly techniques for sustainable design, we seek to explore the aesthetic and experiential meaning of materials (WHY?), and the technical knowledge related to the use of materials and the processes of construction (HOW?). The creative opportunities and design implications of using varied materials, structural systems, fabrication and assembly techniques—both analogue and digital—are elaborated, especially as they determine the artistic, conceptual, poetic, creative, spatial, and experiential aspects of architecture. The studio projects, lectures, and the required building study will focus on the application and integration of knowledge acquired in a parallel "Materials & Assembly" course 48-215.

Prerequisite: 48-200

Corequisite: 48-215

48-215 Materials and Assembly

Spring: 9 units

The fourth semester of architectural studies at Carnegie Mellon University is concerned with the detailed development and refinement of architectural design as informed by the meaning, aesthetics and techniques related to the usage of materials and the process of construction. As part of the technology sequence, 48-215 introduces and examines the fundamentals between design intent and construction materials, the science of materials (performance) and their assemblies. Learning how materials and techniques inform spatial and form making decisions will be a central theme to the semester. Lectures and discussions will focus on the meaning, aesthetics and techniques related to the use of materials and the process of construction. Field trips will provide further depth into these topics. A basic understanding of essential, well-known systems of building construction will be our base line. Discussions and case studies of contemporary systems that extend, experiment and question these known systems will introduce you to the great depth to which this basic knowledge can lead you. Joint assignments with the second year design studio will provide you with an opportunity for an in-depth exploration of these fundamentals of construction through a direct application and synthesis of this new knowledge to your studio project. This course will introduce a basic understanding, selection, design, preliminary sizing and methodology of construction systems organized by the 16 divisions of construction, as defined by the Construction Specifications Institute (CSI) as well as and introduction to the International Building Code (IBC) with special attention given to fire protection, types of construction, and means of egress.

48-217 Structures

Spring: 9 units

Structures is a required course taught in the second year. It is a successor course to Statics, complementing that previous course by emphasizing structural member design in wood, steel, and reinforced concrete; spatial synthesis of hierarchical one-way systems for gravity load; structural types for lateral load including braced frames, shear walls, and rigid frames; introduction to geometric structures such as cable nets, domes, shells, and air-supported structures.

48-240 Historical Survey of World Architecture and Urbanism I

Fall: 9 units

This course cuts a broad swath through time, geography and cultures, surveying critical episodes in the built environment of Europe, the Middle East, Asia, and the Americas from antiquity through the 19th century. Reflecting the inseparable relation between building and human needs, this course is not only a history of architecture, but also a history through architecture. It examines architectural and urban design as a form of cultural expression unique to its time and place. The design, use, meaning and legacy of a building is conditioned not only by the architect's will or the patron's desire, but also by a web of technological, religious, social, cultural, economic, and political factors of the time. This foundation course is the first in the architectural history sequence, and introduces students to the subject and skills of world architectural history. It is a prerequisite for all subsequent architectural history courses. Student work will include several exams and a final.

48-241 Modern Architecture

Fall: 9 units

This survey of modern architectural history lecture course picks up where the historical survey 48-240 leaves off. It focuses attention on the 20th-century, and investigates the web of interwoven ideas and issues that characterize the modern age and modernism. We begin with a look at the "crisis of modernity" that plagued most of western civilization in the late 19th-century, and then survey the major movements of the avant-garde and other responses to modernity, and end with what came to be known as Post-Modernism. We will look more closely at the increasing divide between the disciplinary edge of architecture, and architecture's increasing professionalization in the last century, focusing on how architecture has influenced culture through experimentation and provocative thinking, even when the primary intent was functional, technological, social, political, etc. Emphasis will be placed on the relationship of buildings to the more general cultural, intellectual, and historical circumstances in which they were created. Special attention will be devoted to the important manifestoes, theoretical, and critical writings that so determined the project of modern architecture.

48-250 Context

Fall: 9 units

To be determined by the department

48-300 Architecture Design Studio: Integration I

Fall: 18 units

Design Studio III: Building and Site is a required course taught in the third year. The subjects of the Third Year Fall Semester are the reciprocal orders of buildings and landscapes and the development of the building site. The work builds on knowledge gained in prerequisite and co-requisite courses including 48-312 Site Engineering. This course asks students to continue their investigations into the formal and spatial composition and enquiries of previous semesters with a focus on the following concepts: Occupancy: Social and cultural phenomena, dimension/measurement and cycles of time relating to human and non-human occupancy Site assessment: site inventory at many scales Grading and surface manipulation: compatibility of grading with related technical considerations for water management, ground structures, surfacing, plants, and maintenance Road alignment: design of roads and parking to support construction, service and the anticipated occupancies, design of roads to connect to other roads with appropriate sight lines, stack spaces, and turning requirements, layout and sizing of parking spaces for vehicles Stormwater: volume and direction of runoff water on both the undisturbed and developed areas, storm water surface system, Plants: selection of plants and plant communities with consideration for regional, local, and site-specific factors Prerequisite: 48-205

48-305 Architecture Design Studio: Integration II

Spring: 18 units

The basis for the CMU studio course sequence is the expectation that the student retains and applies knowledge gained each semester to the current studio. The spring semester of the third year of architectural studies at Carnegie Mellon University is concerned with the detailed development and refinement of an architectural design as informed by the technical knowledge of structural systems, enclosure systems and the process of construction. The student is expected to articulate concepts and develop designs with more precision and in greater detail than done in previous studios and courses. In addition to criteria related to the development of design skills appropriate to one's sixth semester of the studio sequence, the following criteria are an explicit part of the evaluation of the student work: Aesthetics: The degree to which the design responds to formal issues as articulated in prior design studios. Structural System: The degree to which the proposed building is presented as a statically stable structure which defines the spatial order and satisfies the architectural intentions made explicit in the project. Enclosure System: The degree to which the proposed enclosure system satisfies the design requirements and responds to the physical phenomena of the environment into which it is placed. Material Selection: The degree to which the selected building materials and their implementation are appropriate to the occupancy, articulate the architectural order, and satisfy the physical design requirements. Constructability: The degree to which the proposed building is developed in response to an understanding of the processes of construction. Presentation: The clarity, craft and completeness of the presentation. Prerequisite: 48-300

48-315 Environment I: Climate & Energy

Fall: 9 units

This course introduces architectural design responses for energy conservation, human comfort, and the site-specific dynamics of climate. Students will be expected to combine an understanding of the basic laws of comfort and heat flow with the variables of local climate to create energy design guidelines for their own work. The state of the art in building energy conservation and passive heating and cooling technologies will be presented, with take-home readings and assignments. To stress the significance of architectural design decision-making on energy consumption and comfort, full design specifications and calculations will be completed for a residential-scale building. Students will compile a professional energy consultant's report, designing the most viable energy conservation retrofit measures for their client from siting, massing, organization, enclosure detailing, opening control, to passive system integration and management. An overview of world energy consumption in buildings and energy design standards will be challenged by lectures on building energy conservation successes, and emerging demands for a broader definition of sustainability. The course will end with a focus on the design integration of natural conditioning systems and the potentially dynamic interface of mechanical systems in small- and large-scale buildings.

48-324 Structures/Statics

Fall: 9 units

To be provided by department

48-332 Teaching and Learning

Intermittent: 6 units

In this course, students will learn about effective strategies for teaching architecture and the built environment. Topics include the cognitive differences between novices and experts, instructional techniques, and goal alignment. As part of the coursework, each student will implement these teaching strategies to design and teach a lesson. Elements of developmental psychology, learning theories, and classroom practices will inform the architectural education lesson. Teaching and learning techniques can be generalized for communication with clients, practice, and the community.

48-338 European Cities in the XIX Century: Planning, Architecture, Preservation

All Semesters: 9 units

The history of the main cities of Europe during the XIX century is a history of change and transformation. The physical environment and the political, financial and administrative structures adapt to the needs of new masses of population and to the challenges of metropolitan life. In some cases, cities even acquire new representative functions, as they become a national capital. This course traditionally offers an overview of the urban culture of XIX century Europe, reconstructing aspects of the broader historical context and then focusing on reading the effects of the XIX century transformations on the physical appearance, structures and image of present-day European cities, such as Paris, London, Berlin, Barcelona, Vienna and Rome. This semester we will add to this analysis, acquired by learning and applying a set of essential questions about XIX century urban transformations, a second look at the image of the city - the issue of how the city is represented and described in the various moments of its Nineteenth century transformation (from historical maps, to paintings, from postcards to literary descriptions). We will try to consider its changing visual representation and the different perception of its character and peculiarities over time, finally discussing how the Nineteenth century image of each city still affects how it is viewed today. We will rely, along with the usual reading materials (articles, book excerpts) also on visual documentation, such as photography and film. The course is based on lectures and discussions and requires personal elaboration, as well as a fair amount of reading and writing.

Prerequisite: 48-240

48-340 Modern Architecture and Theory 1900-1945

Intermittent: 9 units

This architectural history lecture course surveys the modern buildings and literature of the first half of the twentieth century, focusing primarily on Europe but extending also to non-western countries. We begin with a look at the "crisis of modernity" that plagued most of western civilization in the late 19th-century, and then focus on the major movements of both the avant-garde and other responses to modernity from 1900-1945. The course includes lectures, readings, and discussions about a broad range of issues, including 1) Formal tendencies; 2) Theoretical issues; 3) National traditions; 4) Biographical sketches; 5) Significant technologies and materials; 6) Political motivations; 7) Social & cultural influences. Emphasis will be placed on the relationship of buildings to the more general cultural, intellectual, and historical circumstances in which they were created, especially the important manifestoes, theoretical and critical writings that so determined the project of modern architecture. Work for the course involves extensive reading and a major research paper.

Prerequisite: 48-240

48-341 Expression in Architecture

Intermittent: 9 units

This architectural history seminar will explore expression in architecture in its many forms, particularly in written works of architectural theory through the ages. We start with the premise that architecture is not merely pragmatic, technical, or functional: it can express or communicate like a language, it can represent and inspire like many of the arts, it can shape behavior and emote, it can trigger memories, emotions, or meanings. As Isozaki put it: "Architecture is a machine for the production of meaning." We'll investigate many ways that architects have theorized the design process, as well as the forms, materials, and contexts of architecture, to express a myriad of ideas and sensibilities. We'll also look at the ways that buildings can communicate and have meaning, often beyond the intent of the architect, and usually changing over time. Some of the topics to be explored include the classical orders, gothic geometry and mystical light, the theatrical space of the Baroque, architecture parlante, character, and style in the Enlightenment, tectonics as structural expression, political architecture and morality, the aesthetics of functionalism, Expressionism, key terms such as ornament, representation, linguistics, and semiotics, as well as more recent theoretical constructs such as embodiment, materiality, atmosphere, and affect. The work of the seminar will include intensive weekly readings, especially of primary sources by the architects seeking to express ideas, weekly presentations and discussions about the sources, and a term paper on an important theory of expression in architecture of your choice.

Prerequisite: 48-240

48-348 Architectural History of Mexico & Guatemala

Intermittent: 9 units

This course surveys the architecture and urbanism of Mexico and Guatemala from prehistory to the 20th century, focusing on three critical periods of their cultural history and architectural development: (1) the Pre-Columbian development of Mesoamerica, primarily Maya and Aztec, (2) the Spanish colonial architecture and urbanism of the 16th-18th centuries, and (3) the 20th-century search for an appropriate regional and national modernism. When the Spanish conquistador Hernán Cortés landed in 1519 in what is now Mexico, he encountered one of the world's largest and most spectacular civilizations. The Aztec empire, however, was only the latest urban civilizations in a Mesoamerican tradition that stretched back more than 2,000 years. The ensuing European architectural and urban imprints can be seen as both a victory of colonialism's political, social, and architectural ideals, and as a fusion combining European practices with indigenous conditions and traditions. Centuries later, as 20th-century Latin Americans grappled with the challenges of industrialization, economic swings, and political and social revolutions, architects, planners, and clients again sought to reconcile competing visions of national and modern identities. Student work will include a research paper and several shorter written assignments throughout the semester.

Prerequisite: 48-240

48-350 Postwar Modern Architecture and Theory

Intermittent: 9 units

This architectural history lecture course surveys the modern buildings and architectural theory of the post-World War II period. It begins with the cataclysm of WWII and the fundamental shifts it caused on the conception of modernism, technology, cities, and geo-politics. It proceeds to investigate themes such as rebuilding and reconstruction, grand modern masters such as Mies, Kahn, and Le Corbusier, the fascination with technology, megastructures and utopian thought, the need for monumentality, meaning, and regional identity, and the dissemination of modernism from corporate America to the third world. It ends with the rupture in modernism associated with the social revolutions and the rise of a post-modern architecture in the late 1960s and early 1970s. The course includes lectures, readings, and discussions to define the unique character of the postwar period, as modernism both reigned supreme, and began to be questioned. Emphasis will be placed on the relationship of buildings to the more general cultural, intellectual, and historical circumstances in which they were created. Special attention will be devoted throughout the course to the important manifestoes, theoretical and critical writings that so determined the project of modern architecture. Work for the course involves extensive reading, preparing for class discussions, and a major research paper.

Prerequisites: 48-240 or 48-241

48-351 Human Factors in Architecture

Spring: 9 units

Required course Human Factors is an investigation of what makes buildings tick for people: the internal spaces, transitional spaces, transactional spaces, defensible space, owned space, shared space, public space, and most importantly, occupied space. We move up in scale from the individual and group to the community to consider our designers' biases in how we analyze the human needs, how we judge the quality of space and subsequently, how we apply this knowledge to our own design work. Students develop a research question and test it in field research using observation, interviews and surveys. They draw conclusions about the quality of a space and place and how to improve it. Students should leave this class with the ability to discern a problem, experience in applying their understanding of behavioral settings and the human condition to specific research foci, and the ability to use their knowledge and skills deftly in practice, where time and resources are limited. Assignments will be a mix of individual and group work, with emphasis on the latter. There will be an emphasis on reading relevant literature, field investigations and understanding research methods and collaboration for applications in practice.

48-355 Perspective

Intermittent: 9 units

Course addresses perspective on the basis of three distinct understandings of perceptual psychology: 1) A Kinesthetic Basis for Perspective, which is built on the drawing pedagogy of Kimon Nicolaides. It aligns with the transactionalist understanding of perception and considers perspective as partly invented and partly discovered truth. 2) The Order of Appearance, which is built on the early work of the perceptual psychologist, J.J. Gibson, and aligns with the ecological position of Gibson and his followers. It considers perspective as an absolute truth of the visual field. 3) Perspective Imposed, which aligns implicitly with the position of Gestalt psychology. It treats perspective as an imposed schema. Along the way some use is made of on-going design work for subject material. Work is submitted in 3 portfolio submissions of 3-4 weeks duration each.

Prerequisites: 48-135 and 48-130

48-356 Color Drawing

Intermittent: 9 units

The course will use three media, pastels, colored pencils and water color to address the representation of architectural space. Early work will focus on interiors; later work will extend into landscapes. Topics covered in each will be, value, color temperature and use of complementary palettes. Work will be submitted in three portfolios of 3-4 weeks duration. Work will consist of in-class exercises and out of class assignments using subjects of the students' choice. Including in-class work, students should anticipate 9 hours of work per week. Students should anticipate material costs for taking the course of ca. \$150.

Prerequisites: (48-121 and 48-126) or (48-130 and 48-135)

48-368 Rediscovering Antiquity: Travelers, Archeologists & Architects in Mediterranean

Spring: 9 units

The course proposes a journey in the Mediterranean, with special focus on Greece and Turkey, but also travel through time. In fact ancient cities and archeological sites, from the hills of Troy to the archeological sites of Pergamon and Ephesus, to the cities of Athens and Constantinople/Istanbul, will be studied not so much as signs of the important Greek and Roman past of the region, but as the object of late Eighteenth and Nineteenth century rediscovery. The rich vestiges of the mythical past of this region were then brought to the light, in the frame of complex and adventurous missions. The eyes of scholars, travelers and artists filtered and transformed the reality of the ancient objects and places, adding to their fascination and vitality and changing the way we perceive this legacy today. At the same time though, a new political agenda, new biases and new aims were connected with the rediscovery. These in turn influenced not only the way the past of the region was explored and the way the finds were studied and exposed, but also the cultural debate in the rest of Europe, with important effects on the architecture of the main European cities.

Prerequisite: 48-240

48-371 American House and Housing

Intermittent: 9 units

This architectural history course examines the development of American house and housing choices during the period 1850-1975. A recurring picture of the "American Dream" has typically included the image of a single-family, detached dwelling set within its own green yard in the suburbs. However powerful and durable that image is, the history of house and home in America is actually a far more complex story with many different twists and turns. In the course we will look at both urban and suburban housing choices and cultures, ranging from single family detached dwellings to multi-unit housing, and across a social spectrum income, class, race, and gender. Through the use of occasional field trips, we will use Pittsburgh as a touchstone for understanding broader national trends in the history of American urban and suburban housing. The course is organized as a lecture course supplemented with field trips and discussions based on field trips and primary source readings. The additional time slot on Thursday afternoons will be used only when field trips are scheduled. Student work will include a research paper and several shorter written assignments throughout the semester.

Prerequisite: 48-240

48-374 History of Architecture in the Islamic World- A Primer

Fall: 9 units

This course serves as an introduction to the architecture that developed in the Islamic lands over the centuries. The aim of the course is to provide a basic understanding of major epochs and regional variations, examining the social and historical context within which Islamic art and architecture developed. Through lectures, discussion and guided research activities, the students will learn the function and meaning of the most important building types, examine how these types changed over time to adapt to the needs of changing societies, and consider influences and exchanges with other traditions. While the main geographical focus of the course will be on the Mediterranean area, from Moorish Spain to the modern Middle East, the students will have the opportunity to develop independent research projects on other areas of the Islamic world.

48-380 Real Estate Design and Development

Spring: 6 units

This course will provide an overview of the real estate development process and explore the interdependence of real estate development and design. The course will introduce real estate development team members, processes, and phases, including feasibility, predevelopment, construction, and marketing. The course will include a substantial financial component that will introduce students to the basic techniques of property valuation, project budgeting, pro forma analysis, sourcing of financing, and investment analysis. Students will study how market demand, tenant requirements, site constraints, zoning restrictions, and available capital affect design solutions. Course work includes classroom learning, independent reading and exercises, guest lectures, and examination of case studies. The semester's effort culminates in the execution of a team development project based on a current Pittsburgh development project. Teams will complete a basic market analysis, program evaluation, schematic design creation, project cost estimation, pro forma analysis, and evaluation of financial feasibility. Development practitioners will provide a critique of each team's project to offer real world guidance on student schematic designs and feasibility analysis prior to the final completion of the project.

48-381 Issues of Practice

Spring: 6 units

Course description coming soon.

48-383 Ethics and Decision Making in Architecture

Spring: 6 units

Course description coming soon.

48-390 Physical Computing Studio

Spring: 10 units

This collaborative studio course will allow interdisciplinary teams to develop wearables with a focus on assistive technology. The ubiquitous nature of mobile devices coupled with low-cost and easily integrated sensors and actuators make this a good time to approach real problems for a range of users from the physically disabled to athletes. Teams will learn skills in hardware, software, fabrication, and design communication in order to effectively develop and share their ideas.

Prerequisites: 16-223 or 60-223

Course Website: <http://ideate.cmu.edu/>**48-400 Advanced Synthesis Options Studio I**

Fall: 18 units

Having proven competency in the spectrum of skills determined necessary for tomorrow's architect during the first three years of the program, students in their fourth and fifth year are permitted to select from a variety of studio options, each providing the opportunity to build upon or augment some of those skills with new or more nuanced perspectives. All advanced synthesis studios are open to both years, the vertical integration offering enhanced learning opportunities. The content and focus of each studio is governed by faculty interests, which run the spectrum of architectural pursuits, ranging in scale from the design of a piece of furniture to a city and in approach from a comprehensive and complex building program to a critically-driven speculation. They may also be interdisciplinary in nature, taking advantage of the unique juxtapositions made possible at Carnegie Mellon.

Prerequisite: 48-305

48-405 Advanced Synthesis Options Studio II

Spring: 18 units

Having proven competency in the spectrum of skills determined necessary for tomorrow's architect during the first three years of the program, students in their fourth and fifth year are permitted to select from a variety of studio options, each providing the opportunity to build upon or augment some of those skills with new or more nuanced perspectives. All advanced synthesis studios are open to both years, the vertical integration offering enhanced learning opportunities. The content and focus of each studio is governed by faculty interests, which run the spectrum of architectural pursuits, ranging in scale from the design of a piece of furniture to a city and in approach from a comprehensive and complex building program to a critically-driven speculation. They may also be interdisciplinary in nature, taking advantage of the unique juxtapositions made possible at Carnegie Mellon.

Prerequisites: 48-400 and 48-412

Corequisite: 48-415

48-432 Environment II: Advanced Building Systems Integration & Mechanical Systems

Fall: 9 units

To be determined by department

48-440 American Regions & Regionalism: An Architectural History of Place, Time, and Cul

Intermittent: 9 units

Despite the leveling forces of mass culture and globalization, the geographic and social diversity of the U.S. has created distinctive regional mosaics of landscape and architecture. Say New England and images of English Pilgrims, town greens with white framed churches, and industrial mill villages may come to mind. The Southwest conjures different images, perhaps of adobe pueblos, Spanish friars, arid ranches, and the color turquoise. The built environment of the Midwest, the California coast, the Mississippi Delta, and many places in between reflect particular regional identities that have been both unconsciously and consciously created over time. This course examines the historical development of regional patterns in the American built environment. It investigates how and why a region's architectural identity evolved in the ways that it did. To what degree is place something to respond to, to interact with, and to what degree is place something that is created? Our focus will be primarily pre-20th century when the forces of vernacular traditions were stronger, we will also examine more recent trends of regionalism as an aesthetic choice and a theoretical stance.

Prerequisite: 48-240

48-448 History of Sustainable Architecture

Intermittent: 9 units

The History of Sustainable Architecture investigates themes of nature, ecology, pollution and conservation in the built environment and visual arts. The term "sustainable architecture" is a comparatively recent one, arising in reaction to the destructive and toxic nature of the industrial era and its strident ambassador, Modern architecture. Yet, an esthetic and philosophical view of harmony with nature accompanies many forms of historical human activity in the built environment. Similarly, issues of waste removal, mechanical systems and natural materials that characterize current concerns have illustrative historical roots in numerous civilizations going back centuries and even millennia in pre-Industrial or non-industrial cultures. This course will engage texts and examples relating not simply architecture, landscape and urban history, but also art, philosophy and popular culture as a means to understand the many precedents for today's interest in sustainable architecture and planning. The course will examine texts and works by figures including Vitruvius, Pliny, Leon Battista Alberti, Thomas Cole, Frederic Law Olmsted, Buckminster Fuller, Reyner Banham, Ebenezer Howard, Hassan Fathy, Bernard Rudofsky, Norman Foster, Robert Smithson, Andy Goldsworthy and more. Students will be encouraged to apply principles from the class to understanding and execution of work in their own discipline.

48-452 Real Estate Design and Development

Fall: 6 units

This course will introduce the Real Estate development process and explore the interdependence of development drivers and the design process. Classroom learning, exercises and guest-lectures will introduce students to the concepts of market and financial analysis, as well as the basic techniques of budgeting, proforma development, and valuation. Parallel to this investigation, students will evaluate real world developments and interface with the development professionals that executed them to learn how development drivers shaped the development process and decision making. Students will study how market demand, tenant requirements, site constraints, and available capital affect feasibility, and through this the ultimate design solution. The semester's effort culminates in the execution of a mini-development project. Students will work in teams to complete a basic market analysis, program evaluation, schematic design, construction and development cost estimate, proforma analysis, and a determination of financial feasibility. Development practitioners will interface with student teams during this mini-project to offer "real world" guidance on student schematic designs and feasibility analysis.

Prerequisite: 48-305

Corequisite: 48-500

48-453 Urban Design Methods

Fall: 6 units

This undergraduate lecture course introduces urban design history, theory and methods. It is a required supporting course for the Urban Laboratory design studio, and similarly examines urban design at multiple scales: city form and networks, neighborhoods and block structures, streets, public spaces, and urban building typologies. Key issues introduced include the emergence and evolution of urban design as a discipline, economic, social and political factors affecting the contemporary city, and environmental sustainability at the urban scale. A wide variety of cities, projects, proposals and methodologies are examined. Assignments include readings from seminal texts, quizzes, and a final examination.

Prerequisite: 48-305

Corequisite: 48-500

48-454 Futures of the City/Cities of the Future

Intermittent: 9 units

If all design can be read as attempts to predict and to shape the future, then no one looks further into the future than the urban designer and the urban planner. The work in which they are involved often does not materialize in their lifetimes; in fact, the duration of the projects are so long twenty, thirty, fifty and hundred year timeframes, it is more than likely that he or she will pass on before the project reaches fruition. The trouble with predicting the future is that it is so uncertain, so undecided, so unknowable. A brief look backwards reveals that we are not the first generation to consider the future. History is replete with predictions, some of which were actualized, the vast majority of which were not. Today's forecasts for tomorrow vary wildly. A handful of optimists view the future through rose colored glasses, whereby humanity is delivered to salvation via technological wonders and the widespread adoption of common social values. A larger group predicts the end of the world as we now know it, but even they cannot agree on the cause of our demise, with those arguing that climate change will kill us clashing with those convinced that we will be destroyed when robots achieve technological singularity. Shy of total extinction, however, any vision of the future requires designers, and will likely occur in urban (or formerly urban) locations. As of this decade, for the first time in history, more than half of the world's population, almost three and a half billion people, live in towns and cities. Estimates suggest that by 2030 this number will swell to almost five billion.

Prerequisite: 48-205

48-470 Exploring Pattern Through Lamination

Fall: 6 units

Lamination is the process of gluing wood together along the edge or face of a plank. Pattern may be generated in unlimited variety through this process following standard rules of wood working. Generally lamination is unidirectional, however, in this class we will introduce ways to achieve cross directional patterning and the use of inlay to elaborate on the pattern. Topics will be demonstrated in class and assignments relating to the demonstrations will be issued. When demonstrations don't take the entire class the students will work under the instructor's supervision. Students should come to each class prepared to work. Multiple assignments will be given throughout the course. While assignments are process driven, thoughtful, well crafted execution reflecting good design is critical. Projects will be visual statements. Their function will be limited. They will not be furniture. Each exercise will present a series of basic wood working operations, which, when repeated and recombined will become products of compelling visual character. As visual idea statements you will be asked to experiment, invent and explore and take these standard operations in new directions. But as visual idea statements the greatest clarity of vision will be achieved through careful construction.

Prerequisite: 48-105

48-473 Hand and Machine Joinery, New Directions

Fall: 6 units

Hand and Machine Joinery, New Directions is offered in the second half of the fall semester. As the course name suggests, it will teach hand and machine methods for making the basic joints of stick construction in woodworking: the mortise and tenon and the dovetail, while also exploring unique joints which are derived from hand tools, or power tools techniques. It will explore variations in these basic joints which can be altered to meet the myriad unique situations of furniture making. Variations include perpendicular and angled joints with two, three, and more intersecting members. Emphasis will be placed on developing hand tool skills with the chisel, plane, and saw. Sharpening of hand tools will be demonstrated and students will be required to sharpen the tools they use. Joints and fabrication techniques will be demonstrated in class and assignments relating to them will be issued. Demonstrations may not take the entire class time in which case the students will work for the remainder of class time under the instructor's supervision. In class work is an important component of the class, and out of class assignments are also required. Assignments will consist of practice exercises and joints in large stock of softer hardwoods to develop hand and machine skills and knowledge of layouts. Attention will be directed to grain direction, orientation of faces and edges to maximize strength, and accommodation of later actions performed on the intersecting parts (like carving and shaping). The final grade will be based on submission of all assignments, quality of workmanship, and uniqueness of design. This mini course will focus on the development of skills however there will be constant opportunity to incorporate and refine design. There will be hard labor through which you will develop blisters, calluses, muscle, dexterity, and perseverance. You will also develop knowledge of materials and techniques.

Prerequisite: 48-105

48-478 Digital Tooling

All Semesters: 6 units

This course serves as an immersive analysis of the available technologies located in the Digital Fabrication Lab at Carnegie Mellon and beyond. Students begin to understand equipment limits/boundaries, purposes and concepts; and the possibilities that arise from thoroughly comprehending how these tools work. During your Digital Experience, students begin to understand more systematically how to use these tools to their advantage. A better understanding of the equipment proves very useful towards a SoArch Student's 3rd, 4th and 5th years at Carnegie Mellon; but more importantly provides a fundamental understanding of a leading edge technology that will certainly prove itself as an integral tool for any Designer throughout their professional career. It is based on the idea that pushing the limits of design fabrication; comes from knowing the limits of your tools. The course operates by discovering tooling extremes; thus indicating limits, and then incorporating these boundaries (and/or breaking them) with Digital Fabrication methods and tooling; ultimately providing a platform in which students begin to understand and incorporate project efficiency. Prerequisites: Imagination, Laser Cutting, Milling and 3D-Modeling Experience required. (Rhinos 3D Preferred)
Prerequisite: 48-205

48-497 Thesis Prep

Spring: 3 units

The primary goal of this course is to begin the process of formulating a robust research topic in architecture and writing a coherent thesis proposal. A series of weekly workshops, readings, discussions, and guest lectures will explore the difference between design and research in architecture, how different research methods and modes of representation can be leveraged, and how concepts of disciplinarity and "project" can focus a topic. A series of assignments will help students move from general interests in vast topics, to charting a focused, rigorous research process that builds on existing knowledge and attempts to develop new ideas and advances the discipline. Students will begin to identify precedents, key readings and a research bibliography, an overview of the general topic they will research in depth, a detailed plan for a year's worth of independent thesis work, and a well-defined end-product, likely a design proposal. An important task will be to identify advisors who can support, guide, and critique your work, who can act as intellectual collaborators as much as evaluators. The primary deliverable is a substantial proposal for a year-long Thesis or a one-semester Independent Project. This course (or an equivalent approved by the Thesis coordinator) is a pre-requisite for doing a year-long Thesis or semester-long Independent Project in 5th year studio.

48-500 Advanced Synthesis Options Studio III

Fall: 18 units

Having proven competency in the spectrum of skills determined necessary for tomorrow's architect during the first three years of the program, students in their fourth and fifth year are permitted to select from a variety of studio options, each providing the opportunity to build upon or augment some of those skills with new or more nuanced perspectives. All advanced synthesis studios are open to both years, the vertical integration offering enhanced learning opportunities. The content and focus of each studio is governed by faculty interests, which run the spectrum of architectural pursuits, ranging in scale from the design of a piece of furniture to a city and in approach from a comprehensive and complex building program to a critically-driven speculation. They may also be interdisciplinary in nature, taking advantage of the unique juxtapositions made possible at Carnegie Mellon.

Prerequisite: 48-405

48-505 Advanced Synthesis Options Studio III

Spring: 18 units

Having proven competency in the spectrum of skills determined necessary for tomorrow's architect during the first three years of the program, students in their fourth and fifth year are permitted to select from a variety of studio options, each providing the opportunity to build upon or augment some of those skills with new or more nuanced perspectives. All advanced synthesis studios are open to both years, the vertical integration offering enhanced learning opportunities. The content and focus of each studio is governed by faculty interests, which run the spectrum of architectural pursuits, ranging in scale from the design of a piece of furniture to a city and in approach from a comprehensive and complex building program to a critically-driven speculation. They may also be interdisciplinary in nature, taking advantage of the unique juxtapositions made possible at Carnegie Mellon.

Prerequisite: 48-105

48-509 Architecture Design Studio: Thesis I

Spring: 18 units

This is a year-long, independently defined research and design project that takes the place of upper level option studios. Thesis is an opportunity to develop skills, thoughts, and habits essential for future success, including mental discipline; independence of mind and judgment; working with advisors; the capacity to focus and pursue a subject in depth and over an extended time; the ability to design and execute a complex project; the skills of analysis, synthesis, and clear writing; and the self-confidence that grows from mastering a difficult challenge. Thesis topics and research agendas are generated by the student, but must be determined in collaboration with an advising team, and approved by a Thesis Coordinator. The School seeks to encourage an expansive range of rigorous and provocative inquiry as a culminating experience for the B.Arch education, including work that speculates, invents, or improves on existing ideas, practices, or systems through research and design; work that challenges the boundaries of the discipline and the profession, and moves beyond mere practice or solution-based work; work that engages with open-ended and generalizable ideas, as much as with specific situations; work that projects or imagines a better future and an improved world; work that leads to the new knowledge, ideas, understanding, or paradigms. Acceptance into Thesis is dependent on passing the 48-497 Thesis Prep course or its pre-approved equivalent, and submitting a rigorous thesis proposal to the Thesis Coordinator in late August, before the begin of classes. Approval for the 2nd semester is contingent upon successful completion of the 1st.

48-519 Architecture Design Studio: Thesis II

Spring: 18 units

This is a year-long, independently defined research and design project that takes the place of upper level option studios. Thesis is an opportunity to develop skills, thoughts, and habits essential for future success, including mental discipline; independence of mind and judgment; working with advisors; the capacity to focus and pursue a subject in depth and over an extended time; the ability to design and execute a complex project; the skills of analysis, synthesis, and clear writing; and the self-confidence that grows from mastering a difficult challenge. Thesis topics and research agendas are generated by the student, but must be determined in collaboration with an advising team, and approved by a Thesis Coordinator. The School seeks to encourage an expansive range of rigorous and provocative inquiry as a culminating experience for the B.Arch education, including work that speculates, invents, or improves on existing ideas, practices, or systems through research and design; work that challenges the boundaries of the discipline and the profession, and moves beyond mere practice or solution-based work; work that engages with open-ended and generalizable ideas, as much as with specific situations; work that projects or imagines a better future and an improved world; work that leads to the new knowledge, ideas, understanding, or paradigms. Acceptance into Thesis is dependent on passing the 48-497 Thesis Prep course or its pre-approved equivalent, and submitting a rigorous thesis proposal to the Thesis Coordinator in late August, before the begin of classes.

48-530 Human-Machine Virtuosity

Spring: 12 units

Human dexterous skill embodies a wealth of physical understanding which complements computer-based design and machine fabrication. This project-oriented course explores the duality between hand and machine through the practical development of innovative design and fabrication systems. These systems fluidly combine the expressivity and intuition of physical tools with the scalability and precision of the digital realm. Students will develop novel hybrid design and production workflows combining analog and digital processes to support the design and fabrication of their chosen projects. Specific skills covered include 3D scanning, 3D modeling (CAD), 3D printing (additive manufacturing), computer based sensing, and human-robot interaction design. Areas of interest include architecture, art, and product design.

Prerequisites: 16-223 or 60-223

48-531 Fabricating Customization

Intermittent: 9 units

This course relocates the design process from the studio to the lab-workshop, moving design decisions upstream to include considerations of tooling and material processing as inputs for design experimentation. Students in this course will work in partnerships to explore novel methods of robotic metal sheet forming that are borne out of direct experimentation with industrial robotic arms and customized metal forming tools. We will operate in response to two primary motivations: 1. Explore novel methods of customizable robotic metal sheet forming. 2. Speculate upon the potential application of the results at the building scale. Our work will leverage the robustness and precision of industrial robotic arms in conjunction with rule-based, computationally generated geometry to explore highly customizable alternatives to long-standing massproduction metal forming techniques. In situating this as an open-ended series of design experiments, rather than product designs, we seek to produce artifacts that reveal the methods of their production and uniqueness of their material character, while suggesting potential applications at the building scale.

Prerequisite: 48-205

Corequisite: 48-400

48-550 Issues of Practice

Fall: 9 units

Issues of Practice is a required course taught in the fifth year. It consists of three modules: Personal Promotion, Emerging Professional's Companion, and Excursions. The Personal Promotion module provides the students with a framework to create a resume, cover letter, and portfolio. The EPC (Emerging Professional's Companion) provides concentrated study in different aspects of professional practice. The Excursions require students to see how architecture relates to the wider world with architecturally related events that can include volunteer opportunities, lectures, mentorship, or teaching.

Prerequisite: 48-305

48-551 Ethics and Decision Making in Architecture

Spring: 9 units

Ethical Decision Making in Architecture is a required course in the fifth year of the Bachelor of Architecture Degree. It is part of a sequence dealing with professional aspects of the field of architecture, alongside courses like Human Factors, Real Estate Design and Development, and Issues of Practice. It builds on an understanding of the issues of occupancy, economics and practice in design decision making. The course covers basic frameworks of decision making and ethical adjudication through several case studies including Fallingwater, Sydney Opera House, Citicorp Tower, Pruitt-Igoe housing development, Crystal Palace and Kansas City Hyatt. The text for the course is a manuscript by the instructor entitled "Ethical Decision Making in Architecture".

Prerequisite: 48-205

48-558 Reality Computing

Fall

The Adaptive House is the focus of an advanced design studio based around the collaborative development of reality computing applications within a residential prototype. Reality computing encompasses a constellation of technologies focused around capturing reality (laser scanning, photogrammetry), working with spatial data (CAD, physical modeling, simulation), and using data to interact with and influence the physical world (augmented / virtual reality, projector systems, 3d printing, robotics). This studio will use reality computing to understand existing homes, define modes of augmentation, and influence the design of houses yet to be built through full scale prototyping. The objective of the course will be the production of a house that moves beyond the notion of being "smart", but is actively adapted towards its inhabitants' needs and capabilities. Topics of special focus within the course are residential design (John Folan), augmented reality and robotics (Pyry Matikainen), and indoor flying robots (Manuela Veloso and Nina Barbuto).

48-564 Furniture Design & Construction

Spring: 9 units

There is a creative core in people which is much more closely related to the hand than to the head. This core is universal and is the source of the connection that all people can feel with something well made. It is the source of an intrinsic meaning that handmade objects have and that all people understand. This class will attempt to connect the inexperienced maker with the universal meanings that emerge in objects made by hand. It will teach you to trust your eye, hand, and intuition which is the substance of self-reliance. Constructing an object from scratch provides deep personal satisfaction. This furniture studio will seek to generate form in direct response to the material, guided by the capabilities of machines and tools available, while responding to ergonomic considerations. The emphasis will be on the use hand tools and power machinery. There will be two main projects for the semester. A table made of straight components and a student selected piece made of curved and shaped parts. Students will conduct a survey of modern sculptors and furniture to understand the context of studio furniture. The studio will require hand labor in drawing, design and fabrication. Computers may be used to assist design to ease the labor, but the final rendition of the design will be hand drawn full size on ply. This will serve to establish important links between hand and eye/mind, perception and intuition, touch and understanding. The development of these connections between body and nervous system must be established, practiced and reinforced through repetition. It promotes muscle memory that is so essential in all sports and performance skills. Similarly this linkage connects the eye with hand to make drawing more automatic and the representation of an idea /image more spontaneous and expressive.

Prerequisites: 48-105 and 48-473 and 48-470

48-568 Advanced CAD, BIM, and 3D Visualization

Fall: 9 units

This course is designed to introduce a student to advanced software applications, including AutoCAD 3D, 3D Studio MAX, and Autodesk REVIT. Students will learn how to properly set up and manipulate CAD projects integrating all three software applications, replicating real world projects in leading architectural firms. Building information and parametric modeling, animations, materials, lighting, and rendering concepts will allow students to create integrated projects, 3D video animations, and realistic renderings. At the conclusion of this course, students will have projects and animations created and architectural CAD standards outlined. Students should have some familiarity with basic AutoCAD 2D commands. Those who don't have AutoCAD 2D knowledge can contact the professor to arrange for on-line tutorials that need to be completed before classes begin.

Prerequisite: 48-305

48-569 GIS/CAFM

Spring: 9 units

A Geographic Information System (GIS) integrates displays, edits, analyzes, and shares spatial data for informing decision making. Industries benefiting from GIS include architecture, business, city planning, defense and intelligence, education, government, health and human services, natural resources, public safety, transportation, utilities and communications, and urban planning/design. GIS topics include map design and outputs, geodatabases, downloading and importing spatial and attribute data, digitizing, geocoding, and advanced spatial, 3D, and network analysis. Other topics such as raster-vector integration and web-based GIS will also be covered. Facilities management is the practice of coordinating the physical workplace with the people and work of the organization. Computer Aided Facilities Management (CAFM) integrates software tools to streamline operations, boost productivity and develop strategic planning goals for an organization. CAFM topics include space management, asset management, building operations, emergency preparedness, environmental health and safety, telecommunications, and real property and lease management. This course prepares students to understand, maintain, and manipulate spatial and organizational data using world leading software applications. By the end of the course, students will have sufficient background to identify spatial characteristics of diverse application areas enabling them to integrate spatial thinking and analysis into their academic research and careers.

Prerequisite: 48-205

48-576 Mapping Urbanism

Intermittent: 9 units

This seminar provides the critical tools necessary to examine the city as both a representation and a reality in flux. Through an interdisciplinary framework, students study urban history, theory, visual thinking and spatial mapping. Contemporary urban issues are introduced through weekly lectures, readings, and class discussions. Parallel to these urban explorations, students learn to employ a diverse set of representational techniques to create inventive mappings. Upper-level (300 and 400 level) undergraduate students and graduate students are encouraged to register.

48-587 Architecture Lighting Design

Intermittent: 9 units

Through hands-on exploration in the light lab, lecture and discussion, students will develop a design process for lighting people and architecture. Topics will include: Role of the architectural lighting designer in the collaboration process; Establishing design goals and a point of view; Communicating design ideas; Lighting interiors (retail, restaurants, offices, museums, hotels); Lighting exteriors (landscape, buildings, bridges); Technical tools (luminaires, lamps, control and dimming) A large part of class time will be devoted to hands-on experimentation of light. Students will also spend time in the light lab outside of class preparing realized lighting designs. The final design project will include full-scale lighting mock-ups.

Prerequisite: 48-105

48-596 LEED Buildings and Green Design

Spring: 6 units

Green building and sustainable design have been rapidly gaining acceptance in all sectors of the building market. Global issues of energy use, emissions, resource depletion, and land use are forcing building professionals to re-evaluate standard design and construction processes, and look to more environmentally friendly practices. The U.S. Green Building Council (USGBC) developed green building rating systems entitled Leadership in Energy and Environmental Design (LEEDTM) in order to define "green building" by establishing a common standard of measurement. LEED considers green building methods and technologies in several categories including site, water, energy, materials, and indoor air quality, and awards points towards an overall green building rating of certified, silver, gold or platinum. Currently, LEED registered projects make up 3% of the current U.S. commercial building market, and Pennsylvania is the third leading state with LEED registered projects. There is now a demand for design professionals with knowledge and experience not only in sustainable design but specifically with the LEED rating system as well. This course will provide students with background knowledge of the USGBC, the LEED system, as well as referenced standards related to specific topics. The course will benefit greatly from the large number of LEED projects in the Pittsburgh region, which will serve as case studies. Upon completion of the course, students will be prepared to take the LEED Professional Accreditation Exam, which is quickly becoming the standard of recognition for green building professionals.

Prerequisite: 48-315

48-631 Fabricating Customization

Fall

to be created by the department

Prerequisite: 48-205

48-711 Paradigms of Research in Architecture

Fall: 6 units

This course is both an introduction to important models and methods of academic research particularly as they are related to building design issues and a forum for intellectual curiosity. During the initial ten weeks of the semester, the course presents an overview of the field and covers several models of research as they relate to the building design. These will include models of natural sciences, social sciences, sciences of the artificial, engineering and aesthetics in building design. During the final five weeks of the semester faculty both CFA and CIT will be invited to make presentations about their areas of research and the methods they use. These presentations correspond in many respect to those covered in lectures.

48-721 Building Controls and Diagnostics

Intermittent: 12 units

This course introduces the concepts and methods of building diagnostics. It focuses on the empirical evaluation of the built environment (building components and systems, interactions between building, occupants and environmental conditions) in view of multiple performance criteria (thermal, visual and acoustic performance). Field measurement and assessment techniques will be introduced. The empirical methods of building analysis are commonly used to: describe/specify building components; study the real-time behavior of buildings; detect the causes of building failures; and gather data for model validation. The course will address these issues, both theoretically and practically, through the application of: field measurement techniques; physical modeling methods; and computer-aided building modeling. Computer-aided data processing techniques will be applied for the analysis and interpretation of the results of model and field studies. The role of building performance simulation in the area of building diagnostics will be investigated

48-722 Building Performance Modeling

Fall: 12 units

This course introduces fundamentals and computational methods in building performance modeling. Topics include: modeling and design, overview of thermal, visual, and acoustical domain knowledge, integration of performance simulation in computer-aided design, introduction to the application of advanced computational building simulation tools, case studies and design assignments on the application of simulation in the evaluation and improvement of building performance.

48-723 Performance of Advanced Building Systems

Spring: 9 units

Advanced Building Systems Integration This is a graduate level course that focuses on commercial building performance achieved through systems integration. In lectures, class discussion, and student projects, we will explore the topic of building performance, the design and technical strategies that support sustainable high performance; the design, construction and operation processes that are likely to produce sustainable high(er) performance buildings; and the current state of theory versus practice. The course assumes a basic understanding of buildings' impact on the environment, of building design and materials performance, and the calculation of building heating and cooling loads. On that foundation, we will examine the concept of systems integration and how this approach can sustain the occupants and the environment far better than conventional design, construction and operation. Although US climate, building conventions and codes will be our reference point, we will broaden our discussion by using examples and data from many other countries. An essential aspect of our exploration will be identifying successful built projects and examining the factors that may have allowed those projects to succeed. If this course meets its objectives, students who successfully complete the material will understand and be able to discuss sustainable building performance characteristics, will understand the systems integration approach and how it differs from conventional approaches to building design, and will know how to positively affect architectural and engineering decisions to support the design, construction and operation of sustainable high performance buildings.

48-724 Scripting and Parametric Design

Intermittent

This is an introductory course to parametric modeling, which can be taken either as a half-semester assignment-based course, or as a full semester course with a parametric design project component. The course will introduce i) fundamental concepts of geometric modeling including such topics as: spatial coordinates, projections, Boolean operations, formal transformations, freeform surface creation, development and deformations; ii) parametric techniques and tools to model designs parametrically, to construct geometrical relationships among complex shapes, and to deal with constraints and their propagation. The lectures will be on computational geometry that can be applied to architectural design. In addition, the lectures will focus on hands-on techniques that can be applied to the design process, to extend the efficiency and productivity of work during the process. For practical reasons, the course will use Rhinoceros, Grasshopper, Rhinoscript, and .NET framework.

Prerequisite: 48-624

48-725 Real Estate Design and Development

Fall: 9 units

This course will study the real estate development process and explore the interdependence of financial investment drivers and the creation of this built environment. Classroom learning, exercises and guest-lectures will introduce students to the concepts of market, location and valuation, as well as the basic techniques of real estate finance including development budgets, operating proformas, return analysis, and lender requirements. Parallel to this investigation, students will have opportunities to study real world developments and interface with the development professionals that executed them to learn how development drivers shaped the development process and decision-making. The semester's effort culminates in a feasibility study of a development site Pittsburgh. Students will complete a basic market analysis, program evaluation, zoning, deeds, liens and a determination of financial feasibility. Students will study how market demand, tenant requirements, site constraints, and available capital affect feasibility, and through this the ultimate design solution. Development practitioners will interface with student teams during this case study to offer "real world" guidance on student proposals.

48-729 Productivity, Health and the Quality of Buildings

Intermittent

Given the growing demand for green buildings by federal and private sector clients, professional practices are ?tooling up? all over the world to deliver high performance, environmentally responsive, ?green? buildings and communities. However, investments in green, high performance building solutions and technologies are still limited by first cost decision-making, and life cycle tools are still largely inaccessible to professionals. A building investment decision support tool ? BIDS? - continues to be developed by the Center for Building Performance and Diagnostics at Carnegie Mellon University, with the support of the Advanced Building Systems Integration Consortium. This cost-benefit decision support tool presents the substantial cost-benefits of a range of advanced and innovative building systems designed to deliver ? privacy and interaction, air quality, ergonomics, lighting control, thermal control, network flexibility, and access to the natural environment - from field case studies, laboratory studies, simulation studies, and other research efforts. This course will explore the relationship of quality buildings, building systems, and land-use to productivity, health, well-being and the environment. The course will engage students in the literature that relates building design decisions to ten cost/performance impacts: energy, facilities management, organizational change, technological change, attraction/retention (quality of life) of employees, individual productivity, organizational productivity, salvage/ waste, tax/ insurance/ litigation, and health.

Prerequisite: 48-305

48-738 Special Topics: Ecological Footprints

Fall: 6 units

The Ecological Footprint is a measure of the demand that human activity puts on the biosphere. More precisely, it measures the amount of biologically productive land and water area required to produce all the resources an individual, population, or activity consumes, and to absorb the waste they generate, given prevailing technology and resource management practices (Global Footprint Network 2010). This course will engage students in the metrics and impacts of our collective consumption and waste of: -Energy -Materials (Cradle to Cradle) -Food -Water -Transportation -The Integration of Systems towards Quality of Life Starting at the global context, this course will address challenges/opportunities to advance regenerative practices, improving our relationship to nature. Learning from international best practices, we will continue to explore ecological footprints at the global, national, regional, city, neighborhood, building and individual scale. The course will be based on lectures and readings, with assignments and student presentations to fully explore each of the footprint characteristics. Experts on water, energy, materials, food and other resources have been invited to lecture. By mid semester, an application project will be selected for ecological footprint analysis and the development of design, engineering, and operational guidelines towards reducing that footprint. The potential application projects include: the CMU campus footprint and Donner House retrofit; the Energy Innovation Center and education of the trades in reducing our regions footprint; or a new Net Zero building for Carnegie Mellon University. This will be a collaborative effort.

Prerequisite: 48-305

48-739 Making Things Interactive (Graduate)

Fall: 10 units

In this hands-on design-build class you will learn the skills to embed sensors and actuators (light, sound, touch, motion, etc.) into everyday things (and places etc.) and to program their interactive behavior using a microcontroller. Through weekly exercises and a term project the class will introduce basic analog electronics and microcontroller programming, as well as exploration into using kinetics and materials to make the things you design perform. Emphasis will be on creating innovative experiences using simple robotic technologies. The graduate edition of this course will require additional work including a paper that can be submitted to a peer-reviewed interaction design conference such as CHI, UIST, or TEI. Students from all disciplines are welcome: but please note that the class demands that you master technical material. Experience in at least one of: programming, electronics, or physical fabrication is strongly recommended.(Participants will provide their own supplies and materials.)

48-749 Special Topics in CD: Parametric Modeling with BIM

Intermittent

This course is on modeling with an emphasis of producing designs that meet sustainability standards such as LEED, BREEAM, GreenStar, etc. The course is offered either as a half-semester assignment-based mini course (without prerequisites) or extended to a full semester course with a project component (for those students who meet the necessary requirement at mid-semester). Graduate students in Computational Design are required to register for the full 10 units. In addition, some prior programming experience (Visual Basic or C#) would be beneficial although not essential. Overall, the course will introduce: (i): Fundamental concepts of building information modeling Students will be introduced to parametric sustainable building information modeling to create and experiment with performance evaluations. (ii): Parametric modeling techniques and tools Tools will focus on hands-on techniques that can be applied to the design process, to extend the efficiency and productivity of work during the process. For practical reasons, the course will use Autodesk Revit Architecture, Green Building Studio and .NET framework. Overall, the course will introduce: (i) Fundamental concepts of building information modeling. Students will be introduced to parametric sustainable building information modeling to create and experiment with performance evaluations. (ii) Parametric modeling techniques and tools. Tools will focus on hands-on techniques that can be applied to the design process, to extend the efficiency and productivity of work during the process. For practical reasons, the course will use Autodesk Revit Architecture ®, Green Building Studio and .NET framework.

Prerequisite: 48-205

48-752 Zero Energy Housing

Fall: 9 units

Net zero energy construction has gone from concept to policy in just a few years, but built examples are still rare. What does it take, technically, to achieve net zero and what else, beyond technical requirements, advances or impedes a net zero future? 48-752 is a graduate level class that explores net zero energy design and construction in the residential sector. Through case studies and applied projects, we will explore what it takes to achieve quantitative net zero in residential buildings while maintaining occupant comfort and satisfaction. In locations where net zero is now required, we will examine the results of those requirements. At the outset, we will discuss specific definitions of a net-zero building and the implications of each definition. Through case studies, lectures, field trips, outside reading and assignments, we will examine how a net-zero building is achieved, including the use of renewable energy to achieve the net-zero balance. We will apply lessons learned from metered examples to real sites and to new design or renovation projects in Pittsburgh and will use simulation software to test and quantify the impact of our design/renovation strategies. We will also compare our strategies to requirements in US codes and rating systems such as IECC-2012 and LEED for Homes to evaluate their impact in moving the US residential sector toward much higher performance buildings. Although our focus is residential, many of the concepts and strategies we cover have parallels in the commercial sector. Students who enroll in the class must know how to calculate without software heat loss and heat gain for a small building. You are also expected to have a fundamental understanding of residential design and construction, plan reading and mechanical systems; US residential materials and construction methods for net zero will be covered in class.

48-753 Urban Design Methods

Fall: 9 units

This course introduces urban design history, theory and methods of analysis and representation. Urban design is examined at multiple scales: city form and networks, neighborhood and block structures, streets, public spaces, and urban building typologies. A wide variety of cities, projects, proposals and methodologies are examined with a special focus on urban sustainability in the contemporary city. Assignments include readings from seminal texts, presentations and discussions, graphic assignments and a final project. A required course for Master of Urban Design students, it is also open to fourth and fifth-year architecture undergraduates as well as graduate students in related programs.

48-795 LEED, Green Design and Building Rating in Global Context

Spring: 6 units

LEED, Green Design and Building Rating in Global Context is a graduate level mini-course that examines holistic, integrated strategies for sustainable building design, construction and operation. The course is organized within the framework of the US Green Building Council's Leadership in Energy and Environmental Design (LEED) Rating System: location, site, water, energy, materials, and the interior environment. Within that framework, we explore strategies promoted within LEED and compare/contrast them with strategies in the rating systems of other countries. We also consider additional ways to encourage development of better buildings, e.g., codes and standards, incentives, and project delivery methods. The course focuses on the concepts underlying rating system credits, the national contexts that can produce different rating systems, and substantive improvement in building performance. This course provides the foundation for taking USGBC's LEED Green Associate exam. More importantly, students who successfully complete the course will understand buildings' powerful impact on the environment and equally powerful strategies to address those impacts. There are no prerequisites for this course. However, because the course moves quickly and we are discussing improvements to building practice, a basic knowledge of the vocabulary, design, construction and operation of buildings is assumed.

Prerequisite: 48-315

48-801 Office Visits

Fall: 6 units

Each candidate will arrange with their home office a virtual 'visit' for members of the degree program and organize presentations of the projects, methodological challenges, recurring problems, best and worst practices within the context of their office experience. Asynchronous Course Delivery (Fall 2014) -> September 18, through December 7, 2014 Online Synchronous Course Conclusion (Fall 2014) - December 8-11, 2014

48-802 Principles of Research I

Fall: 6 units

Candidate's current knowledge of problems, methods and outcomes based on their professional work. Overview of the eight knowledge areas as existing disciplines and their potential place in them. Asynchronous Course Delivery (Fall 2014) -> September 18, through December 7, 2014 Online Synchronous Course Conclusion (Fall 2014) - December 8-11, 2014

48-803 Areas of Practice

Fall: 6 units

Candidate presentations of area(s) of expertise summarizing the methods and problems that are prevalent; using case studies to establish a situated approach to research. Asynchronous Course Delivery (Fall 2014) -> September 18, through December 7, 2014 Online Synchronous Course Conclusion (Fall 2014) - December 8-11, 2014

48-804 International Exchange I

Fall: 12 units

Conduct workshops for collaborative research and information exchange meetings with EU cohorts visiting from the Université Toulouse III - Paul Sabatier, Doctoral Programs in Architecture. Asynchronous Course Delivery (Fall 2014) -> September 18, through December 7, 2014 Online Synchronous Course Conclusion (Fall 2014) - December 8-11, 2014

48-805 Directed Study I

Fall: 6 units

Prepare the first publishable article under the supervision of the advisor, based on the current professional practice record of the candidate. Submitted to a committee of faculty for approval. Asynchronous Course Delivery (Fall 2014) -> September 18, through December 7, 2014 Online Synchronous Course Conclusion (Fall 2014) - December 8-11, 2014

48-809 International Exchange II

Spring: 12 units

Visit Université Toulouse III - Paul Sabatier, Doctoral Programs in Architecture and participate in collaborative research and information exchange meetings with EU cohorts, based on the cohorts current knowledge base culled from their practice experience. Asynchronous Course Delivery (Spring 2015) - January 18, through May 13, 2015— Online Synchronous Course Conclusion (Spring 2015) - May 14 through 17, 2015

48-810 Comparative Analysis of US and EU Practices

Spring: 6 units

Practices in the building sector vary considerably in the US versus the EU. The instructor will provide a rich collection of national and international initiatives in the AEC domains and include a stimulating series of site visits to important installations in the area. Asynchronous Course Delivery (Spring 2015) - January 18, through May 13, 2015— Online Synchronous Course Conclusion (Spring 2015) - May 14 through 17, 2015

Art Courses**60-101 Concept Studio: The Self and the Human Being**

Fall: 10 units

Concept Studio: The Self and the Human Being is first of a sequence of six studio courses designed to develop a personal approach to generating art and to learning transferable conceptual skills. The topics of the first three Concept Studios are addressed through a sequence of structured, media-independent projects. Open to freshmen admitted to the School of Art, or by instructor permission.

60-104 Contemporary Issues Forum

Fall: 6 units

This introductory class presents to students a diverse range of contemporary issues in the visual arts. It is organized in a thematic way rather than chronologically. There will be readings, discussions, and papers. Lecture/discussion format. All students are required to attend the School of Art lecture series. Open to freshmen in the School of Art, or by instructor permission.

60-109 Adventures in Arts Time

Spring: 9 units

An introduction to the essential elements, structures and dynamics of Arts Histories? from the earliest Prehistoric periods to the end of the Ancient World. It will take an anthropological approach, focusing on humans as extraordinary culture-makers, whose definition is inseparably tied to making Art and Symbolic-Objects. The approaches to study and research will utilize multi-media and explore the History of the Arts in multidisciplinary ways - across Time and Space. It will start with a somewhat linear approach towards cultural artifacts and remains, surveying them from the earliest periods down towards our own Common Era. It will also take a multi-cultural perspective relating and comparing cultures across different parts of our world. The methodologies will include investigating ?Time-Capsules? which will focus on interrelated groupings of related cultural materials organized as ? People, Places, Objects, Events and Ideas. The intention is to create a meaningful ?Matrix? which brings together the most significant examples of Art, Architecture, Design, Music and Drama. The setting of the Carnegie Museums will be used as a creative-context for interacting with potent symbolic examples of Human-creativity in ways that transcend what is normally experienced in printed words and pictures. There will also be the creation and development of an ?I-Story? by the participants. Each student's I-story will be a form of a personal journal (but including multimedia) relating their own individual historical research experiences ? to the larger and more universal sequences (cycles) and archetypes of the World of Arts Histories. These creative narratives can evolve into and become important direct connections between the great cycles of Human History and the adventure of Evolution - and the individual student's own narrative and story of growth and development in the present day World of education and learning.

60-110 Electronic Media Studio: Introduction to the Moving Image

Spring: 10 units

Electronic Media Studio: Introduction to the Moving Image is an introduction to the computer as a dynamic tool for time-based media production. In this course students develop skills in digital video and audio production through the exploration of narrative, experimental, performance, documentary and animation themes and forms. Historical and contemporary works are presented and discussed to provide a context for studio projects.

60-125 Introduction to 3D Animation

Spring: 6 units

[IDeATe course] This mini on introductory animation is designed to explore the wonderful world of computer animation from initial concept to final production. In a mixture of class discussions, training workshops, and guest lectures from industry experts, students will become acquainted with the necessary skills needed to create their own characters and animations. Both artistic and technical elements within animation production will be covered, and workshops will help to delve into more specific elements within a topic. Some specific topics include modeling, rigging, character/object animation, texturing, and rendering. By completion of the course, students will understand how to use Maya - the software used by many industry professionals - and be capable of taking on more advanced courses related to animation, vfx, and video games in the future.

Prerequisites: 62-150 or 15-104

60-126 Introduction to Performance Capture and Rendering

Intermittent: 6 units

[IDeATe course] This mini is designed for those interested in the growing world of performance capture and visual effects. Utilizing the advanced motion capture facilities at Carnegie Mellon and the Kinect, students will learn how to capture motion from performance and apply it to CG characters and objects. While this technique is found in many video games and vfx movies, it has the ability to create endless possibilities within the realm of computer graphics and experimental animation/art. Students will also become more familiar with the process of rendering to create the necessary polish for their animations/visualizations. CG Lighting, camera work, and material shading are just a few of the many topics covered in this course.

Prerequisites: 15-104 or 62-150

60-130 3-D Media Studio I

Fall: 5 units

An introduction to three-dimensional form. Various materials and methods are explored through projects covering a broad range of sculptural concerns. Art majors must complete one Mini-1 course and one Mini-2 course to satisfy the 3DI requirement. Students are required to select two of the following four sections: The Structural Imagination (Wood and Steel); Clay Sculpture; Small Metals; and Hey Robot, Let's Make Something. Materials fee may be required. Open to freshmen in the School of Art, or by instructor permission.

60-131 3D Media Studio II

Spring: 5 units

Three unique mini classes offer an introduction to basic language and approaches of sculptural practice. Multiples, Mold Making, and Casting: focus on mold making, casting, and creating multiples for editions and parts; Small Metals; and Mixed Media/Mini-Installation: : emphasis on mixed media and provides a hands-on approach to working with a variety of materials in order to combine those materials with an array of connectors and/or create a composition with a relationship of objects in ?space?. By using a conglomeration of fabricated, found, natural and altered elements students expected to learn a variety of skills and vocabulary related to mixed media sculpture, assemblage, mini-installation and site work. Art majors must complete one Mini-3 course and one Mini-4 course to satisfy the 3DII requirement. Materials fee may be required. Open to School of Art freshmen or by instructor permission.

60-141 Black and White Photography I

Fall and Spring: 10 units

This course will teach you the basic craft of photography from exposure of the negative through darkroom developing and printing to print finishing and presentation. Content includes student presentations, class discussions, shooting assignments, darkroom sessions and class critiques. We will concentrate not only on the technical aspects of photography, but also the aesthetics of seeing with a camera. The course concentrates on photography as a fine art — what is unique to it and the concerns that are shared with other visual arts, such as composition, tonal values, etc. and aims to equip students with an understanding of the formal issues and the expressive potentials of the medium. Lab fee and 35mm manual camera required. Each student is responsible for the cost of paper and film.

60-142 Digital Photography I

Fall and Spring: 10 units

This course explores digital photography and digital printing methods. By semester's end students will have knowledge of contemporary trends in photography, construction (and deconstruction) of photographic meaning, aesthetic choices, and the use of color. Students will learn how digital cameras work, proper digital workflow, RAW file handling, color management and Adobe Photoshop. Through the combination of the practical and theoretical, students will better define their individual voices as photographers. No prerequisites.

60-150 2D Media Studio: Drawing

Fall: 10 units

This course focuses on the language, materials and concepts of drawing as foundation for all the visual arts. Initial emphasis on the development of perceptual, analytical, and structural drawing skills with increasing attention to idea development. Exposure to methods of creating pictorial and illusionistic space; recording the external world of light and form; and making visible the internal world of the heart, the mind, the soul. Experience with line, texture, tone, shape and mass; in a variety of wet and dry drawing media. Open to freshmen in the School of Art, or by instructor permission.

60-160 2D Media Studio: Imaging

Spring: 10 units

A continuation of Two-Dimensional Media Studio: Drawing. Includes an expansion of drawing to include multimedia approaches, painterly issues, digital input/output and work with digital image processing tools.

Prerequisites: 60-157 or 60-150

60-200 Sophomore Review

Fall and Spring

Students present their work and their ideas about their work to a faculty committee. A successful review is required for advancement to the junior year. Although this is a non-credit course, it is required of all Art (BFA, BHA, BSA, and BCSA) sophomores.

60-201 Concept Studio: Space and Time

Fall: 10 units

Concept Studio: Space and Time is a continuation of Concept Studio: The Self and the Human Being with a focus on space and time through projects of increasing complexity. Such topics as biological time, historical time, psychological time, celestial time, clock time, and public space, private space, mathematical space, and virtual space are addressed through projects. Open to sophomores in the School of Art, or by instructor permission.

Prerequisite: 60-101

60-202 Concept Studio: Systems and Processes

Fall: 10 units

"Systems and Processes" A continuation of Concept Studios: The Self and The Human Being I with a focus on systems and processes. The utility, discovery, and the generation of systems and processes are addressed through projects. Open to sophomores in the School of Art, or by permission of instructor.

60-203 Concept Studio: EcoArt

Intermittent: 10 units

An interdisciplinary studio course that provides an introduction to an art practice focused primarily on ecology and the environment. Combines the exploration of the history of environmentalism and ecological art with the production of creative projects to address related issues such as sustainability. Shorter initial exercises and collaborative projects will precede and evolve into larger and more extended individual and/or collaborative projects. Considers both indoor and outdoor sites with an emphasis on context and the use of natural and recycled materials. Open to freshman and sophomores in the School of Art and to students in other disciplines.

60-204 Concept Studio: Networked Narrative

Intermittent: 10 units

Networked Narrative is a studio class that uses social networking sites such as Facebook, Twitter and YouTube as venues to develop fictional stories. The class will explore traditional and experimental narrative forms in a variety of media. Students will develop and produce narrative events that are exhibited on their fictional character's various social networking sites.

60-205 Modern Visual Culture 1789-1960

Fall: 9 units

Explores the diverse roles of artists in the complexity of modern society from the Industrial Revolution through 1960. Contextual issues include the relationship of artists and art to culture, politics, economics and modern technologies. Attention is paid to the decline of patronage, the diminishing role of the academy and the emergence of an avant-garde and art promotion. Open to sophomores in the School of Art, or by instructor permission.

60-206 Contemporary Visual Culture 1960 - Present

Spring: 9 units

This course traces the shifts in art from late Modernism until our After Post era. It will examine the diversity of art produced, as well as the critical ideas that arose over a span of 60 years. The rise of a pluralist / conceptual art will be discussed within the context of social change, technology and globalization. Open to sophomores in the School of Art, or by instructor permission.

Prerequisite: 60-205

60-210 Electronic Media Studio: Introduction to Interactivity

Fall: 10 units

Electronic Media Studio: Introduction to Interactivity is an introduction to software programming and physical computing within the context of the arts. In this course students develop the skills and confidence to produce interactive artworks using audiovisual, networked and tangible media. This fall, Section B (taught by Paolo Pedercini) has an emphasis on interactive game design.

60-215 Visualizing Issues with Images and Sound

Intermittent: 5 units

In this mini, students will use documentary photography to explore their lives and immediate communities to help better understand and explain the issues facing their generation. Students will choose a topic such as the uncertain economy, environmental concerns or diversity and produce a series of images and conduct audio interviews within the mini term. Emphasis will be placed on aesthetics and skills needed to be a competent storyteller while learning values that are crucial for explanatory visual reporting. We will also look at the work of other photographers who have used this method to better understand society. Knowledge of Photoshop and Garage Band is helpful, but not required.

60-220 Technical Character Animation

Fall: 10 units

[IDeATe course] With an emphasis on character animation, this course will explore the whole production pipeline of 3D Animation from initial concept to rendered result through the use of Maya. Through a series of technical assignments, in class demonstrations, and guest lectures from industry professionals, students will come to learn the basic principles of animation and work up to more advanced techniques. Some specific animation areas that will be covered include locomotion, pantomime/acting, dialogue, set driven keys, and blend shapes. Students will also learn more technical/advanced approaches to other production areas such as modeling, texturing, rigging, rendering/lighting, and layout. Please note that there may be usage/lab fees associated with this course.

Prerequisites: 15-104 or 62-150

60-223 Introduction to Physical Computing

Fall: 10 units

[IDeATe portal course] Physical computing refers to the design and construction of physical systems that use a mix of software and hardware in order to sense and respond to the surrounding world. Such systems include digital+physical toys and gadgets, kinetic sculpture, functional sensing and assessment tools, mobile instruments, interactive wearables, etc. This is a project-based course that deals with all aspects of conceiving, designing and developing projects with physical computing: the application, the artifact, the computer-aided design environment, and the physical prototyping facilities. The class consists of students from different disciplines who collaboratively synthesize and implement several systems in a short period of time. The course is organized around a large set of essential skills that students must gain in order to effectively tackle physical computing problems. It is then deployed through a series of quick group projects that utilize the essential skills and challenge students to not only consider HOW to make things, but also for WHOM we design, WHEN the time is ripe, and WHY the making is worthwhile/necessary. Upon completion of this course the students will be able to: work in a mixed physical-digital environment and laboratory, make effective use of standard hardware and software tools for physical computing, approach complex physical computing problems with a systematic overview that integrates iterative research and design steps, generate systems specifications from a perceived need, partition functionality between hardware and software, produce interface specifications for a system composed of numerous subsystems, use computer-aided development tools for design, fabrication and testing and debugging, evaluate the system in the context of an end user application or experience. Please note that there will be usage/materials fees associated with this course.

60-233 Portraiture: The Space Between

Intermittent: 10 units

There is a distance there. To me it's often a picture of the space between us. - Alec Soth Portraiture holds a unique place within photography for its direct, consensual and often collaborative relationship between the subject and the photographer. This course will explore theoretical and practical aspects of portrait photography in both studio and environmental settings, providing students with an understanding of the genre and the technical ability to create portraits in a variety of locations and conditions. Students will gain knowledge in the development of portraiture through the work of notable figures in the medium's history, including August Sander, Dorothea Lange, Richard Avedon, Milton Rogovin, Platon, Rineke Dijkstra and Alec Soth, while utilizing film and digital equipment to learn studio techniques, approaches to artificial and natural lighting, image processing and presentation. Class discussions, readings and critiques will provide an outline for completing both single and serial image assignments.

60-240 Unfolding Environments: The Intersection of Person and Place

Intermittent: 10 units

This course will use photography and visual narratives to look at our surroundings. Assignments will focus on image sequencing and editing, combining the practices of portraiture, landscape, still life and observational photography to create narrative work that explores the complex connections between people, objects and the spaces they inhabit. Through the semester, students will strengthen their understanding of the ways in which these tangible and abstract elements of our environments work together, while also developing their technical abilities by working with color and black and white images, natural and artificial lighting and digital workflow. The course will explore the medium's history and contemporary practice through class presentations and the study of work and books by notable and emerging figures in the medium, including Robert Adams, Rineke Dijkstra, Carolyn Drake, Wayne Lawrence, Milton Rogovin, Judith Joy Ross, Michael Schmelling, Stephen Shore, Alec Soth, Zoe Strauss, Larry Sultan, Carrie Mae Weems and Susan Worsham. Discussions, readings, studio visits and critiques will provide an outline for completing assignments.

60-241 Black and White Photography II

Fall and Spring: 10 units

This course extends the traditional darkroom process of silver printing from Black and White Photography I, with an emphasis on aesthetic development, personal artistic growth, and formal image evaluation. Skills covered include medium and large format cameras, advanced darkroom printing techniques, exhibition presentation, and film scanning for inkjet output. Studio work involves both group critique and individual direction from the instructor. Students should expect to produce a finely-printed body of work by the end of the semester. Prerequisites: 62141 or 60141 or 51265 or consent of instructor.

Prerequisites: 51-265 or 60-141 or 62-141

60-244 Contemporary Photo Theory

Intermittent: 9 units

Because, you know, the photographs are more a question than a reply. (Sebastiao Salgado) A photograph is a moral decision taken in one eighth of a second, or one sixteenth, or one one-hundred-and-twenty-eighth. (Salman Rushdie) This seminar investigates current topics in photography and the image; our goals are twofold: identification of photo theory as it applies to current practice from both the viewpoint of maker and consumer. The course is designed to address philosophical issues for photographers working now and will favor conversation over written work; students are expected to fully participate in critical analysis and discussions. Readings include works by Roland Barthes, Stephen Shore, Susan Sontag, Hollis Frampton, John Szarkowski, Robert Adams, Italo Calvino, Berenice Abbott, John Berger and James Elkins. No pre-requisites.

60-245 Portrait Photography

Intermittent: 10 units

Portrait Photography explores the emotional and visual process of collaboration between subject and photographer that creates a photograph. We'll use cameras of all formats and levels of sophistication to create portraits in the studio and on location. We'll find and exploit available light and create artificial light to complete our vision, and we'll explore a wide range of darkroom strategies to support and add richness to our final print. Through film and video we'll meet some of the masters of this form like Arbus, Newman, Avedon and Penn, and we'll take advantage of any opportunities to visit exhibitions and photographers studios. Lab fee required.

Prerequisites: 60-141 or 51-265 or 62-141

60-250 2D Media Studio: Painting

Fall and Spring: 10 units

A pragmatic introduction to the tools, materials, and techniques of painting, including instruction in the fabrication of sound painting supports and the application of permanent grounds. Students become conversant with the range of visual options unique to the vocabulary of painting. Open to sophomores in the School of Art, or by instructor permission.

Prerequisites: 60-151 or 60-160

60-251 2D Media Studio: Print Media

Fall and Spring: 10 units

An introduction to print media with emphasis on reproductive image making in the context of historical and contemporary practice. Students will be introduced to print processes such as intaglio, stencil, relief, linocut, lithography, serigraphy, and digital applications. Informed by readings, presentations on artists, and visits to museums, students will develop a body of work informed by and extending the traditions of print media. Open to sophomores in the School of Art, or by instructor permission.

Prerequisite: 60-160

60-257 Introduction to Computing for Creative Practices

Fall: 10 units

This course is an introduction to Java programming for designers, architects, artists and other visual thinkers, using the popular "Processing" Java toolkit for interactive graphics. Intended for students with little or no prior programming experience, the course uses interaction and visualization as a gateway for learning the traditional programming constructs and the fundamental algorithms typically found in a first course in programming. Students will become familiar with essential programming concepts (types, variables, control, user input, arrays, files, and objects) through the development of interactive games, information visualizations, and computationally-generated forms.

60-280 Introduction to Contextual Practice

Spring: 10 units

For some time now art has moved out of gallery and museum spaces and into all facets of public life, where complex social situations and diverse audiences have become important parts of the work. In the past this might have been called Public Art, but today new strategies are being used that challenge public art's tradition of static sculptures and embrace more dynamic forms of public engagement. As its name implies, Contextual Practice embraces the context or social conditions in which an artwork exists as part of the material of that work. Evolving out of the history of site-specific, conceptual, and performance art practices, Contextual Practice covers a range of exciting new methods to making art in the public including street art, interactive social media, environmental art, hacktivism, participatory art, guerilla performance, project-based community art, and urban interventions. Students in this field-based class will create projects that work with the social dynamics of a variety of on and off-campus and online public contexts. We will research new trends in public engagement through art, architecture, and design, as well as politics, ecology, sociology, and economics. Fundamentally, this class asks students to experiment with how their art practice can intersect directly with the real world (outside of the traditional art venues) and how they can proactively create new sites and audiences for their work.

60-298 Photography and Reality

Intermittent: 10 units

Photography's unique relationship with reality is the source of the medium's tension as well as its creative potential. This class will explore photography's tenuous status as a vehicle for truth and interrogate the mysterious rift between the "real world" and photographic representation. Students will be introduced to historic and contemporary practices, from "documentary style" images to abstract formalism. We will examine the history of art photography utilizing the book form with an emphasis on how meaning is created through the photographic series and sequencing of images. A series of slideshows, readings, and discussions will provide a framework for conversation and critique of student projects. Recognizing photography as a conduit for examining our ideas and experiences of the world, students will be expected to conceive, execute and present photographic projects that articulate a deeper understanding of the potential of photographic communication and will encourage a closer look at the photographic illusion as it appears in our ever expanding digital image-sphere.

60-340 The Ballet Russe (The Russian Ballet) and its Artists

Intermittent: 9 units

The leading artistic position of the French Avant-Garde in the 1910's and 1920's was partly predicated on the assembly, meeting, collaboration and cross-influence of artists from all over Europe. The visual artists, musicians and performers brought with them specific aspects of their native heritage, therefore contributing to the enrichment of the general cultural scene. Paris with its cultural focal point the Ballets Russe became a melting pot of creativity.

60-347 Global Perspectives for Art

9 units

We find ourselves in a constantly intensifying global reality where increasingly there is a tendency beyond traditional boundaries. This seminar will explore the aesthetic concepts of the large historic cultures where there are bodies of articulated aesthetic philosophy: Western traditions from Plato to Heidegger, including Islam as integral to the Abrahamic/biblical traditions; the vast and rich array of aesthetic thought in Hindu, Buddhist, and Shinto cultures. In some specifically interesting cases, we will explore particularly small, isolated or ancient cultures, such as the Hopi or the Aborigines of Australia. In each case, we will explore ideas related to cardinal cultural 'objects' of each culture: architecture, painting, sculpture, performance/ritual, dance, film, and other media. We will expand our thought through various appropriate readings and discussions. Research themes can include: iconoclasm, cultural cooption, cultural orthodoxies and purifications, cultural transferences, cultural isolation and extremes, multiple cultural exchanges over long periods of time, cultural antagonism, cultural extermination and genocide, cultural transplantation, cultural destruction and warfare, cultural distinctions, etc. Of particular interest will be the study and understandings of the roots of the iconoclastic, anti-art traditions and their constant struggle and interaction with the meanings and power of the icon, symbol and image. Students will be expected to do specific presentations based on research topics as well as our readings. A final research paper/project will be the major outcome of the course, and in some cases, this will be combined with an artistic project or performance.

60-351 Art & Religion

Intermittent: 9 units

The Art and Religion course-seminar will explore several major artistic manifestations prompted by religious beliefs during the history of art. Emphasis will be on the arts, although general historical eschatological and philosophical explanations will be assessed as well. Major religions will be brought to discussion in one or several of their artistic manifestations. The course-seminar will be based on discussions facilitated lectures given by the professor, in addition to student research presentations.

60-352 NOISE: Toward a Critical Theory of Sound and Hearing

Intermittent: 9 units

This seminar will explore audio art in its widest sense: sound sculpture and installations, radio art, the soundtrack, just about anything audible but not conceived as music. Special focus on the production (and reception) of sound by artists, amplifying those creative efforts that, in having explored acoustics, soundscapes, and listening, might also serve to inspire students to incorporate sound in their own work. Contemporary critical theory, by and large, is still glaringly silent on aurality and auditory phenomena; it seriously fails to consider sound as an object of study, instead focusing quite exclusively on visual culture (film, TV, video, computer screens, which are, of course, technologies of vision and sound). This seminar will address this roaring silence by examining some suggestive but disparate theoretical work related to sound and by engaging with a range of artistic practices that explore the production and reception of sound itself.

60-353 Media Performance: History, Theory, and Contemporary Practice

Intermittent: 9 units

During the last decade of the twentieth century, new technologies have transformed the way we think about live performance. By examining the use of media (analog and digital) across the areas of sound/music, dance, theater, performance art, gaming, and installation, this course will traverse multiple theories and practices of performance history. With an eye to how changing theories of performativity have influenced how artists think about what it means to "perform," this seminar, in a sense, will be engaged in both philosophical and aesthetic research about how technology has changed the conventions of performative artistic practice. What was the role of technology in the dematerialization of the object of art? How have ideas about virtual, parallel worlds changed the way artists think about the "performing body?" If technology once acted as a prosthetic device, increasing an artist's sensual and perceptual world, what happens to the role and impact of an artist's work in the seemingly inert realms of programming or the increasingly autonomous areas of Robotic Intelligence?

60-355 Rights to Representation: Indigenous Peoples and Their Media

Intermittent: 9 units

For decades anthropologists have been "picturing" others, in images as well as in words. This course explores the turn-around: when those who have been subjects of description take the opportunity to represent themselves. After a brief history of visual anthropology, we will concentrate on modes of representation developed by indigenous peoples. We will explore the meanings of "indigenous," in connection with various modes of representation, including film, dramatic performances, art, and the Internet. During the semester, we will compare-across time and space—the purposes for which media are used, the transmission of cultural values in media, the organization of production, and the intended audience. Anthropological method and theory will guide our inquiries. Course materials include disciplinary readings, documents dealing with indigenous rights, and examples of the work of indigenous peoples.

60-356 Curators, Artists, Audiences & International Markets

Intermittent: 9 units

How does art and artists get selected for museum shows, collections, and biennials? This course offers students an in-depth view into the multifaceted elements of the markets that influence curators, artists, and audiences. The Global Art Market is a complex structure comprised of many parts and it has been evolving for centuries. The class will provide students with a solid foundation about the history of the art market in order to gain a perspective about the rise and power of the art market today. We will examine who are the current players and operational mechanisms. We will investigate the following: Who are the key players? Cities?, Collectors? Professional training? And, investigate Institutions and organizations that influence the acceptance of certain artists, the rise of certain ideologies and the contraction of others. Visits to several institutions, discussions with collectors and auction sites will also occur. An analysis of the 56th Venice Biennale as a point of reference will occur in order to demonstrate why this international show has a particular slant and how the director's point of view influences the selection of artists and themes. Focus will be on the expansion of emerging markets and the influence the art world on line has on artists, curators and audiences.

60-357 Picasso & 20th Century Art

Intermittent: 9 units

The greatest artist of the twentieth century, Picasso, invented or participated in most of the major styles of modern art. His artistic genius and visual inventiveness will be explored from 1894 (age 13) to his death in 1973 (age 92), against the background of eight decades of modern art. The focus of the investigation will not be limited to psychological and iconographic factors, but will be discussed in the historical and artistic context of his time.

60-358 Art and Biology

Intermittent: 9 units

A studio-laboratory art-making course designed to explore interactions between art and biology. It is an opportunity for students interested in interdisciplinary concepts to work both in a studio art environment and a biological laboratory. Students have the opportunity to experiment creatively with scientific media such as electron and video-probe microscopy.

60-360 Feminism - Art - Theory

Intermittent: 9 units

What happened when the women's movement and the art world encountered each other? What is the relationship between the theory of art and the theory of feminism? or between the practice of art and the practice of feminism? This course will take place on campus, and at the Mattress Factory, where I am curating an exhibition, "Feminist and?", which will open September 7th. The course will cover themes such as the gendered nature of culture; the practices of history and criticism; the interrelation between feminist activism and art practice; notions of the aesthetic and if there are feminine or feminist aesthetics and representational forms; body, sexuality and representation; the representation of gendered national and racial identities. It will do this through looking at artworks, and through close readings of texts. Some of the material will engage with sensitive issues and challenging images, particularly around sexuality, and students taking the course must be prepared for and accepting of this. At the same time, full debate will be encouraged. The course is open to all students; preference will be given to MFA, senior and junior students.

60-362 Art Writer

Intermittent: 9 units

Description TBA

60-366 Culture in the Public Realm

Intermittent: 9 units

The seminar offers a discerning critical overview of key concepts about culture, public space & the public sphere. We will introduce & critically explore the historical, theoretical & practical production & use of 'public space', & art/culture beyond the museum or gallery. We will consider the historical evolution of the city as both an actual & theoretical entity. The class will explore urban environments in terms of economics, demographics, political, cultural production & psychology & the city of Pittsburgh will function as our site laboratory. We will inquire about the function of public art? what happens when space is required for the public realm for a means of cultural production that aims to yield some form of transformative effect for the public? or citizens at large. Moreover the term "public" is an important topic to be investigated: Who is the public? Who is the audience? This interdisciplinary course will consider & examine the interplay of artists & their public & how certain belief systems of a society at a specific time are able to influence a culture's perception of art. What is the role of the artist, critic, curator & urban planner in relation to the public & what is at stake in utilizing public space as a platform for art & other forms of cultural production? We will reflect on why have we become in recent times so preoccupied with public space as a platform for cultural production. Changing attitudes among artists & in museums have played a role in this cultural shift & theory. We will query a range of cultural mediums in order gain insights into the construction of public culture. The means to inspect the varied issues will go beyond assigned readings: it will include class discussions, personal reflections, writings, videos & guest speakers from the field of architecture, public policy, art, & public art. A conjoint class student project will take place to further probe this subject.

60-370 An Aesthetics of Hip Hop Seminar

Intermittent: 9 units

This seminar course will examine artworks informed by or in dialogue with hip hop culture. Particular attention will be paid to visual artists who came of age during the post civil rights, global economics era? a time period between 1965 and 1984, birth years labeled the hip hop generation. We will draw connections between on-going ideas addressed in the art world: aesthetics, identity, culture; and the content of hip hop's visual, technological and performative expressions. There will be weekly lectures, film screenings and assigned readings. Performance will be evaluated based on overall participation in the following: class discussion, homework assignments, mid-term essay and final research paper.

60-371 Breathless: International New Wave Cinemas

Intermittent: 9 units

What does Jean-Luc Godard's "Breathless [A'bout de souffle] (1959) have in common with Wong Kar-Wai's "In the Mood for Love" [Fa yeung nin wa] (2000)? What does Satyajit Ray's "Pathar Panchali" (1955) share with Mark LaPore's "The Glass System" (2000)? By examining an array of films from the classic days of International New Wave Cinemas, beginning with French Nouvelle Vague, Indian "Parallel Cinema," as well as German, Italian and Japanese innovations and moving to contemporary (and experimental) film movements in Iran, Korea, Hong Kong, Eastern Europe, and the US, we will explore the ways a handful of young directors found novel ways to fund and shoot their movies in direct defiance of commercial, narrative, and cultural norms. By focusing on mise-en-scene over thematics, on-site locations over studios, lesser-known actors over box-office idols, and small production teams over professional crews, these directors were able to turn lo-fi aesthetics and financial shortcomings into a radical new filmic style. Especially central here will be how forms of cinematic experimentation translated internationally—and how these approaches continue to challenge hegemonic forms of media culture.

60-373 Aesthetics from a Global Viewpoint

Intermittent: 9 units

The arts and their making is a behavior that differentiates our species. Artistic/aesthetic differentiation is a global phenomenon occurring since the dawn of our species. This seminar will explore the articulated aesthetic philosophy of large historic cultures: Western traditions from Plato to Heidegger, including Islam as integral to the Abrahamic traditions along with the vast and rich array of Hindu, Buddhist, and Shinto aesthetics. These broader traditions may be examined along with additional examples from small, isolated or ancient cultures, such as the Hopi or the Aborigines of Australia. Across cultures, we will explore the aesthetics of cardinal cultural "objects" (architecture, painting, sculpture, performance/ritual, dance, film, and other media) through readings and discussions. Each student's individual definition of the nature of the arts will be constantly measured with and against the ideas of other cultures, all developing an interactive and integrative dialogue. Other issues include: the study and understandings of the roots of the iconoclastic traditions and their constant struggle and interaction between the meanings of the icon and the image; the notion of cultural "otherness"; and how aesthetic problems manifest themselves in our world in immediate and violent ways; and the evolution of the drive for the preservation of cultural memory in light of recent destructive events in Afghanistan and Iraq.

60-375 Art History/Theory: Contemporary Likeness, Identity and Culture

Intermittent: 9 units

The issue of identity in the visual arts emerged in a new light with the shift from a modernist to a postmodernist paradigm since the mid 20th century. When we speak of identity, what do we mean? How does cultural identity contribute to the formation of personal/private identity & vice-versa? How is this reflected in an artist's work in this time? This class will examine the evolution of human portrayal from the time of Andy Warhol to present. Through readings, discussion & presentations the class will focus on how identity & human portrayal has evolved over time & how theory, popular culture, the cult of the 'glam celebrity,' & technology have played an influential role in reshaping the concept of human portrayal & identity-each challenged the hierarchical pretext regarding the portrait & images of likeness in our culture today. Thanks to photography & cyber-technology no longer is a portrait revered as a unique or rarefied object but a conglomeration of cultural influences. We will look at the works of a diverse range of artists, as well as non-artists, & consider how media affected the evolution of the portrayal of the human face & creation of persona. Images of individuals were once viewed as a primary indicator of national identity, social status, religious belief, as well as a signifier of historical events influenced by particular ideologies. Nowadays images of the self and others, prompt viewers to consider a wide range of psychological, spiritual, & political information beyond visual manifestation. Two basic questions "Who are you?" & "What is art?" often come together in the contemporary portrait. Most portraits are negotiations between identity & representation, between being a subject & portraying a subject. Representations of people represent a mark of contemporary life that personal identities have become fractured, complex, & splintered, and that they are in a state of constant re-definition.

60-376 Large Format Photography: The Antiquarian Avant-Garde

Intermittent: 10 units

This course takes part in the anti-digital movement by exploring the roots of photography. Students will shoot with an array of large format cameras and use 19th and 20th century processes to create "one-of-a-kind" photographic images. Course topics include non-silver printing processes, pinhole photography, and contemporary tin-types. Prerequisites: 60-141/62-141/ equivalent or consent of instructor.

60-377 Picasso and 20th Century Art

Intermittent: 9 units

The greatest artist of the twentieth century, Picasso, invented or participated in most of the major styles of modern art. His artistic genius and visual inventiveness will be explored from 1894 (age 13) to his death in 1973 (age 92), against the background of eight decades of modern art. The focus of the investigation will not be limited to psychological and iconographic factors, but will be discussed in the historical and artistic context of his time.

60-380 Color Photography and Digital Output

Fall and Spring: 10 units

This is a course using digital photography with digital printing methods. Students will gain an understanding of color theory and aesthetics, while better defining their individual voices. By semester's end, students will have a finely printed body of work using Mac OS, RAW file handling, color management and Adobe PhotoShop.

Prerequisites: 51-265 or 60-141 or 62-141

60-381 Museums and other Exhibition Spaces

All Semesters: 9 units

This class provides students with an introduction to the history and function of museum/art spaces and an understanding to the effect of museum exhibitions on our notion of history, arts, culture and society. This course is geared to artists as they prepare to go into the post-graduation enigmatic art world and for students desiring to pursue a career in curating. Focus is on the actual and ideal museum and art galleries, alternative spaces, biennials, art collectives, virtual options as well as a variety of venues to showcase art and culture. It will analyze not so visible skirmishes, hidden economics, and the complex ways artists and curators interact with institutional power. We will concentrate on showcases for art in the Pittsburgh region and visits to museums and exhibitions will be an integral part of this course. Topics to be covered through lectures, discussions and readings include: national galleries, city museums, art centers, artists spaces, museums, as treasuries of culture and of cultures, museum architecture, the idea of the canon in art, political correctness in exhibitions, collections and collecting, ethical issues, acquisitions and de-accessions, design and installation, conservation, sculpture gardens, private houses as museums, donor memorials, museum operations, museum shops, and the role of museums in contemporary society. We will explore controversies relating to museum acquisitions and to the looting of cultural goods.

60-382 Theory and Practice of the Art Museum

Intermittent: 9 units

This class is an introduction to and overview of the missions, operations and history of museums, focusing on art-related institutions such as galleries, and non-profit spaces. The course will provide a broad introduction to the field of museum operations. Topics included will be the history and philosophy of museums, the social, economic and political trends that shape museums; the staffing, management and financing of museums; and the multiple functions of museums - collection and care of objects, exhibition design and interpretation, education programs, research activities and public relations. Discussions will also address cultural policy change as society has evolved and new historical and theoretical models have risen over the past two decades. The course will combine lectures, both by the instructor and visiting lecturers; discussion of readings and videos; field trips to museums; and a semester-long group project.

60-392 Inner Geographies

Intermittent: 9 units

Inner Geographies: On Discovering the Inward Landscapes and Journeys of the Mind and Body This course will discover and explore the inward subconscious topologies of perception, thought (logics), memory, imagination, intuition, the hypnogogic (between dream and waking), dreaming, telepathy, meditation and trance in relation to artistic and other forms of creativity (writing, science, and technologies). The general purpose of the course is to familiarize students with their own unique individual and specific patterns of creativity and thereby reveal new artistic and other unanticipated disciplinary potentials projects. Through simple exercises these aspects of the creative mind and body will be revealed and explored, noted, organized and mapped toward simple formal objects and outcomes, and at the same time, toward a chosen artistic projects or research. All students will evolve a final project. Our texts will include: Anton Ehrensweig, "The Hidden Order of Art", Edward Hall, "The Hidden Dimension", Gaston Bachelard, "The Psychoanalysis of Fire", Carl Gustav Jung, "The Red Book", Martin Heidegger, "Being and Time", and other excerpted texts. Students will be expected to learn, articulate and use new creative mental tools and methodologies in the creation of their projects.

60-397 Art, Conflict, and Technology in Northern Ireland

Spring: 12 units

Art, Conflict and Technology in Northern Ireland is a 9-unit course cross-listed in the School of Art and the Department of English, with a required 3-unit recitation in the Robotics Institute. Throughout the term students will be introduced to a history of social strife in the North of Ireland from the 1960s to the present, and efforts to reconcile differences in the contemporary period. We will consider the influence of advancing technology on how narratives are shared within a community and worldwide. We will reflect upon and analyze a variety of literary and visual art sources from the chosen time period, while also learning how to create mixed-media projects using Gigapan and Hear Me systems from Carnegie Mellon's CREATE Lab in the Robotics Institute. If you have ever considered how artists explore societal strife through their writing or visual arts practice, if you are interested in the social and political influences of evolving technology, or if you are a practicing artist who uses advancing technology as a tool for individual expression, this integrative course is for you. Throughout the semester we will examine the practice of a range of visual artists that include Rita Duffy, John Kindness and Willie Doherty and writers and dramatists like Dermot Healy, Patrick McCabe and Christina Reid. Students will learn how to use CREATE Lab's Gigapan and Hear Me systems as platforms for exploring the content presented in class and for the development of final projects. We will travel to Belfast for spring break 2015, to meet a variety of writers and artists whose work we will study, and stakeholders in reconciliation efforts throughout the region. In addition to weekly lectures on Thursdays throughout the term, students will have a six-week lab on Tuesdays.

60-398 Social History of Animation

Intermittent: 9 units

Social History of Animation will investigate the history of animation from early experiments with trick film through the development of major studios, to independent and web based work. Social movements and technological innovation will be analyzed and discussed in relation to the effects they had on animators and their work. This class will read related texts and view US and international examples to explore animation as a means for personal expression and as a reflection of the context in which they were made.

60-399 Art History/Theory Independent Study

All Semesters: 9 units

A tutorial course in which an Art student works individually on a self-generated project under the supervision of a School of Art faculty member. Prior to enrolling in Independent Study, the student must complete an "Independent Study Proposal" form (available in the bins on the 3rd floor of CFA) which is signed by the faculty member and the Assistant Head of the School of Art. Prerequisite: Art junior or senior status, or by instructor permission.

60-400 Senior Review

Spring

Students present their work and their ideas about their work to a faculty committee. This review affords graduating students the opportunity to analyze and summarize their work, and to engage a faculty committee in discussion about issues that face an artist preparing to enter a career in art. Although this is a non-credit course, it is required of all Art (BFA, BHA, BSA and BCSA) seniors.

60-401 Senior Studio

Fall: 10 units

Students initiate a comprehensive two-semester project in the first semester to be continued and completed in the second semester of their senior year (60-402). Each student pursues an ambitious and cohesive body of work with guidance by a team of School of Art faculty. Multimedia, multidisciplinary, and collaborative work is encouraged. Studio work is supplemented by group critiques, workshops on writing, professional presentation skills, career preparation, and technical instruction as needed. Attendance at all 5pm School of Art Lecture Series events is required for this class. Open to seniors in the School of Art, or by instructor permission.

60-402 Senior Studio

Spring: 10 units

Students continue a comprehensive two-semester capstone project. Each student pursues an ambitious and cohesive body of work with guidance by a team of School of Art faculty. Multimedia, multidisciplinary, and collaborative work is encouraged. Studio work is supplemented by group critiques, workshops on writing, professional presentation skills, career preparation, and technical instruction as needed. Attendance at all 5pm School of Art Lecture Series events is required for this class. Open to seniors in the School of Art, or by instructor permission.

60-403 Extended Studio

Fall and Spring: 10 units

Extended Studio allows students to work individually or collaboratively on a self-generated body of work or special project under the supervision of the professor. Group discussions, visiting artist presentations and critiques supplement individual meetings with faculty. Extended Studio can be used in conjunction with Senior Studio to develop more ambitious projects. Open to School of Art seniors.

60-406 Advanced ETB: Internet Resistance

Intermittent: 10 units

Through booms and crashes, colonizations and disruptions, IPOs and LOLZ, Internet has been a spectacular laboratory of social conflict. But what can artists do on the net beside tweaking their pitiful portfolios and sinking into social media malaise? Internet Resistance is both a schizo-seminar about critical issues in cyberculture and a trans-media studio to develop terrible ideas for the networked society. Topics/assignments may or may not include: mememaking, netporn & rule 34, online hustling, net.art, start-up totalitarianism, slacktivism, conceptual hacking, artist as troll & troll as artist, cyberwarfare, artsy browser plug-ins, New Aesthetic, Open Source, and much more.

Prerequisites: 60-110 or 60-210

60-408 Advanced ETB: the Manipulated Moving Image

Intermittent: 10 units

The manipulated moving image has virtually unlimited potential to visually represent events, scenarios and forms that have little or no relation to our experience of the tangible, extant world. In this course you will use digital and analog tools and techniques and your imagination to create movies that do not represent the way the world is, but how you might want it to be and/or what you are afraid it might become (Utopian/Dystopian impulses, Eros and Thanatos). The manipulated moving image is a somewhat awkward but more inclusive word than "animation" for moving image forms that include: animation, motion graphics, compositing and visual effects in various combinations and permutations. In a way, digital tools have allowed moving image-makers to create works that have less to do with film and more to do with music and painting. Some of the techniques we will explore include: object animation, cutout animation, pixilation, collage, rotoscoping, motion tracking, and compositing. There will also be a focus on audio production and post-production with an emphasis on audio-visual relationships. The primary software tools students will be instructed in and use include Adobe After Effects, Photoshop, and Apple Logic Pro.

Prerequisite: 60-110

60-409 Advanced ETB: Video & Performance

Intermittent: 10 units

This studio course will concentrate primarily on the historical and ongoing relationship between video and performance. That said, this course will be flexible enough to allow students to create video, performance and video/performance projects. For structured projects, all students will be expected to participate in performance. Class time will be spent considering the history of performance and video/performance, viewings of primarily video/performance works to provide background and inspiration, presenting and critiquing student projects and studio time to work on projects. Technical instruction in video editing, compositing and effects, audio recording/editing and midi applications will be offered on an as needed basis.

Prerequisite: 60-110

60-410 Advanced ETB: Moving Image Magic: Visual Effects, Animation and Motion Graphics

All Semesters: 10 units

Fly like Harry Potter, return to the Land of Oz, journey into the farthest reaches of the universe, or take a head-trip into the inner reaches of your subconscious. It's all possible in Moving Image Magic! This course serves as an introduction to the creation of personal extraordinary cinematic visions using a variety of analog and digital tools and techniques. These include: stop motion animation, compositing, motion tracking, digital matte painting, miniatures, rotoscoping, text animation and motion graphics. The primary software tools that students will use are Adobe After Effects CS3 Pro and Adobe Photoshop CS3 extended.

Prerequisite: 60-210

60-412 Interactive Art and Computational Design

Intermittent: 12 units

This is an advanced studio course in arts-engineering and new media practice, with a special emphasis on information visualization and software art. Topics surveyed in the course will be tailored to student interests, and may include: experimental interface design, game design, real-time audiovisuals, locative and mobile media, computational form-generation, image processing and vision-based interactions, simulation, and other topics. Through a small number of exploratory assignments and a public capstone project, students will bolster interdisciplinary problem-solving abilities and explore computation as a medium for curiosity-driven experimentation. Enrolling students are expected to have demonstrable programming skills, without exception, beyond the level of an introductory class such as 15-110. Although the course will provide technical overviews of major visualization toolkits (including D3, Processing, and openFrameworks), assignments may be executed in the student's preferred programming environment. Graduate students should register for section 60-412 or 62-726 (12 units), which meets with the undergraduate sections 60-412 and 51-482 (10 units).

Prerequisites: 15-110 or 60-112

60-413 Advanced ETB: Experimental and Abstract Animation

All Semesters: 10 units

Adv. ETB: Experimental and Abstract Animation — This course will explore experimental and abstract animation from a fine arts perspective and emphasize exploratory, formal and cultural/political motivations. Exploratory is the important term here as students will experiment wildly to develop a personal vision and method of creating one's work. Using a variety of strategies, techniques, and tools students will create experimental and/or abstract animations. Some of the the animation techniques explored will include: 3D stop motion digital photography, copy machines, drawing (analog & digital) painting (analog & digital), cutout, collage, scanners and more. There will also be a strong component on developing audio production and post-production skills with an emphasis on audio-visual relationships. The primary software tools include Adobe After Effects and Photoshop, and Apple Logic Pro. This course is especially suitable for those students who are interested in creating animations using their drawing, painting and object making skills.

60-414 Advanced ETB: Animation Art and Technology

Spring: 12 units

Animation Art and Technology is an interdisciplinary course cross-listed between Art and Computer Science. Faculty and teaching assistants from computer science and art teach the class as a team. It is a project-based course in which four to five interdisciplinary teams of students produce animations. Most of the animations have a substantive technical component and the students are challenged to consider innovation with content to be equal with the technical. The class includes basic tutorials for work in Maya leading toward more advanced applications and extensions of the software such as motion capture and algorithms for animating cloth, hair, particles, and grouping behaviors. The first class will meet in CFA room 303.

Prerequisite: 60-110

60-415 Advanced ETB: Animation

Fall: 10 units

This studio will introduce students to a variety of 3-D computer and 2-D drawn animation techniques. The class will look at and discuss examples of historic and contemporary animation. The students will explore animation through a variety of short experiments and develop individual projects that use animation as a means of self expression.

Prerequisite: 60-110

Course Website: <http://graphics.cs.cmu.edu/courses/AAT/index.htm>**60-416 Advanced ETB: Documentary Storytelling**

Intermittent: 10 units

In this class students will develop projects which use a variety of narrative concepts to convey stories in new ways. We will begin with a core practice around video, audio, and expand into internet media, performance, physical media and installation. Emphasis will be placed on story structure and strategies for choosing a media most appropriate to the narrative as well as the desired audience. Works by Janet Cardiff, Errol Morris, Spalding Gray, Werner Herzog, Laurie Anderson, This American Life and others will be mined for inspiration. With permission of instructor. We will also examine and discuss a range of historical and contemporary strategies employed by art makers who have used forums from on-line and virtual spaces to physical and site specific venues to expand and explore the relationship between the art object and the audience.

Prerequisite: 60-110

60-417 Advanced ETB: Video

Intermittent: 10 units

This course offers an in depth exploration of video as a tool for creative expression. Topics for investigation and discussion will include: histories of experimental video, contemporary trends in the field, technological developments, performativity, perception and manipulation of time, and theories of representation. Additionally this course will provide instruction in advanced production and post-production techniques, including lighting, editing, compositing, 2D animation, graphics and sound design.

60-418 ETB Studio: The Interactive Image

Intermittent: 10 units

60418 The Interactive Image (Golan Levin). This course is an introduction to the use of interactive graphics as an expressive visual tool. It is a "studio art course in computer science," in which the objective is art and design, but the medium is software. Absolutely no previous programming experience is necessary. Rigorous exercises in a Java-based OpenGL graphics environment will develop the basic vocabulary of constructs that govern static, dynamic, and interactive form. Topics include the computational manipulation of: point, line and shape; texture, value and color; time, change and motion; raster, vector and 3D graphics; reactivity, connectivity and feedback. Students will become familiar with basic software algorithms, computational geometry, digital signal filtering, kinematic simulation, and the application of these techniques to aesthetic issues in interaction design. This course can be repeated with the permission of the instructor.

60-419 Advanced ETB: Experimental Game Design

Intermittent: 10 units

Experimental Game Design: Playing Stories is a hands-on game design course focused on innovative and expressive forms of gameplay. The emphasis is on the complex relationship between storytelling and games: from point-and-click graphic adventure games to AI-driven interactive narratives. The class involves frontal lectures, design exercises and in-depth analysis of works from the digital arts and the independent gaming world. This installment of Experimental Game Design does not require any substantial coding experience but all students will be required to tackle some programming and produce visual content.

Prerequisite: 60-210

60-421 Computing for Live Performance with Max/MSP/Jitter

Intermittent: 10 units

This hands-on and highly interdisciplinary studio course is an introduction to the use of Max/MSP/Jitter, a visual programming environment for controlling interactive music, audio, video, and many other electronic media. For more than 25 years this software has been used by artists, musicians, and stage designers to create their own custom programs for algorithmic compositions, interactive installations, live environments and real-time performances. The simple visual interface of Max/MSP/Jitter allows non-programmers to create their own software without having to learn or to write traditional "code". Instead, users connect together pieces from a vast library of functional objects that manipulate and control sound, video, and other effects (such as DMX lighting) in response to sensors like cameras, microphones, game controllers, MIDI devices, and custom electronics. Students will be exposed to the fundamentals of multimedia programming in Max, the basic building blocks of sound and video, and techniques for integrating data from external sources, such as the popular Arduino microcontroller. They will also gain the practical knowledge and problem-solving skills to develop and design their own interactive installations, sculptures, and instruments for performance-based art or experimentation. No previous programming experience is necessary. Prerequisites: familiarity with the Mac OS.

Prerequisites: 60-110 and 60-210

60-422 Advanced ETB: Experimental Animation

Spring: 12 units

[IDeATe course] This class will explore animation from the student's perspective with a sense of investigation toward both form and content. Topics in the class will include non-linear narrative, visual music, puppet and non-traditional materials, manipulation of motion and performance capture data, immersive environments.

Prerequisite: 60-110

60-423 ETB Studio: Audio Visual Systems and Machines

10 units

The idea of a synaesthetic bonding of sound and image is a recurring motif in art, design and cinema; new technologies provide powerful new tools with which to explore that idea. Major topics in this studio course will include: static and dynamic visualizations, visual notation and scoring systems, information sonification, sound for film and animation, and interactive systems for audiovisual play and performance. We will also give attention to psychoacoustics, computer graphics, sound synthesis and analysis techniques, abstract film, and other related fields. The first half of the semester will focus on rigorous weekly assignments aimed at exploring creative mappings between the auditory and visual domains. The second half of the course will develop individual projects, culminating in an evening of public installations, screenings and performances. This course is cross-listed between the Schools of Art, Design and Music.

60-425 Advanced ETB: Live Video

Intermittent: 10 units

Advanced ETB: Live Video - Using analog and digital tools, software and hardware, students will create independent and collaborative live video performances and events. Additionally we will engage in study and discussion around issues of liveness, mediation, representation and embodied experience.

60-428 ETB Studio: Information Visualization

10 units

Traditionally the tool of the statistician and engineer, information visualization has increasingly become a powerful new tool for artists and designers as well, allowing them to present, search, browse, filter, and compare rich information spaces in order to reveal thought-provoking but otherwise hidden narratives. Like many visualization courses, this class will examine computational techniques for displaying temporal, spatial, hierarchical, and textual data. The class will also focus on visualization strategies from the "designer's perspective," exploring how to decipher and represent data in ways that make it meaningful for others, and on critical and conceptual applications of visualization from the "artist's perspective." Emphasis will be placed on the origin of data, as well as what information is worth visualizing and why. This course is heavily project-oriented; students should have programming skills or an interest in learning how to apply computation to their work.

60-430 Advanced SIS: Open Sculpture

Intermittent: 10 units

Sculpture is perhaps the broadest field among the contemporary visual arts. Through its privileged relationship to the physical world and the viewer's body, sculpture is the glue that connects the intermedia practices of object, installation, interactive art and performance. In this class we build on skills and concepts learned in 3D media 1 and 2 to develop students' individual approach. Students define independent responses to topics proposed through discussion of contemporary sculptors. Emphasis is placed on individual development. Students are encouraged to explore interdisciplinary approaches.

60-431 Advanced SIS: Installation

Intermittent: 10 units

This course explores a broad range of sculptural issues concerning the practice of Installation Art. Studio focus on relatively large scale works which often involve an ensemble of objects or phenomena in a particular space. Both temporary and permanent works are addressed. Emphasis on research about "place" and the proposal process for a specific context. Various strategies, methods and materials investigated through projects, readings, presentations, discussions and field trips. Exercises and projects assigned initially, but students expected to establish their own projects later in the semester.

60-433 Advanced SIS: Clay Sculpture

Intermittent: 10 units

Clay is a primary building block of sculpture. This supple, responsive and versatile material is being incorporated into the work of many contemporary artists today. This class will ask students to create projects that explore the use of clay as a medium in the context of their own work. It is intended both for students who would like to specialize in clay sculpture, as well as students who work primarily in other mediums. Lectures will be presented on various approaches and techniques of clay artists, as well as other historic and contemporary artists. A notebook methodology will be employed for recording progress. Class critiques will stress group participation to broaden viewpoints and sharpen critical abilities. The majority of class time will be for studio projects. The use of mixed media is allowed. A materials fee is required.

60-435 SIS: Metals

Intermittent: 10 units

Studio focus on fabrication using light metalworking techniques including forming, joining, and finishing. Metalsmithing and jewelry techniques will be explored in the context of sculptural issues. Metal stretching, forging, brazing, texturing, small scale casting and coloring are also presented. Slides looking at small scale metalwork, as well contemporary sculpture using metal techniques will be presented periodically. Metals provided include copper, brass, and bronze sheet and wire. Materials fee will also cover silver solder and other expendables.

60-436 Advanced SIS/ETB: Digital Fabrication for the Arts

Intermittent: 10 units

This is a class about making physical objects for sculpture, installations, and other art practices using computers and digital fabrication machinery. The tools will be object modeling software packages, rapid prototyping technologies, and computer numeric controlled (CNC) machining technologies. The facility of such tools in the making of multiples, mechanisms for kinetic/mechatronic work, morphology generated by code, and objects that mirror the forms of contemporary mass-produced design will be explored. A smattering of techniques for modeling different types of shapes and functionalities will be covered. That the hand, mind, and eye of the artist remain their primary tools, even in this environment of machinic ubiquity, is a primary revelation of the class. The physical still evades the virtual's desire to simulate it, predict it, and form it.

Course Website: <http://teach.alimomeni.net>**60-437 Advanced CP/SIS: Environmental Sculpture**

Intermittent: 10 units

Studio focus on sculpting with the environment. Includes object making, installations and site work with an emphasis on ecological materials, growing systems, environmental impact and related issues. Students required to explore and develop proposal-making skills in order to acquire permission for sites in which to implement projects. Both individual and collaborative projects are possible.

60-438 Advanced SIS: Intimate Objects

Intermittent: 10 units

The intimate object - exploring the issues of small scale sculpture. This class will deal with the creation of objects that require a one on one interaction with the viewer. Unlike much heroically scaled sculpture, there is a distinctly personal and intimate connection that these objects engender. The class will look at historical examples, as well as 20th century works starting with the dada and surrealists. Problems of small scale sculpture will include topics such as the miniature versus actual size, the nature of materials, the issues of craftsmanship, the problem of preciousness. This class is open to advanced sculpture students working in any media.

60-439 Advanced SIS/CP: Hybrid Instrument Building

Intermittent: 10 units

This course introduces students to the theories, practices, aesthetics and communities surrounding the design, building and performance with hybrid interactive instruments. We espouse an expansive definition of the word instrument that includes "a device for the production of sound/music", as well as "a means whereby something is achieved, performed, or furthered" (from merriam-webster.com. We study the process of translating gesture into another sensory medium (e.g. sound or light). Our approach to instrument design will depart from the double meaning embedded in the notion of composing instruments: first, consideration of instrument building as an act of composition; second, instruments that compose of their own right. While emphasis is placed on musical instruments, course work will also encompass instruments that produce light, image, movement, etc. This course unfolds in two phases: literature review and individualized projects. The first half of the course will introduce students to a wide range of existing examples from contemporary music and composition, installation art and human-computer-interaction. Students will study theoretical and computational frameworks for working with gesture in instrument design. Topics of interest include: gesture data acquisition, data analysis, and mapping gesture data to hybrid-software-hardware computational systems that generate sound/image/movement. We will investigate the software and hardware technologies underlying the design and fabrication of hybrid instruments with electronics, sensors, signal processing, digital fabrication. The second half of the course will allow teams of students to choose an area of specialization, design and fabricate a functioning instrument. The course culminates in an event where all students demonstrate their final instruments in a performance setting.

Course Website: <http://teach.alimomeni.net>

60-441 Advanced CP/SIS: Urban Intervention

Intermittent: 10 units

This course introduces students to theories, practices, and communities for critical investigation of urban spaces and play within them. The course unfolds along two parallel trajectories: research (literature review, lectures, readings, demonstrations) and design (three iterated individualized projects and a fourth larger scale final project). The first half of the course will introduce students to a wide range of theories and techniques within urban intervention that draw from fluxus, the situationist international, activism and hacktivism, as well as public policy, philosophy, psychology and economics. Students will study theoretical and practical frameworks for artistic intervention into public urban spaces, while concurrently researching actual sites and communities within Pittsburgh for experimentation. Students are required to conceptualized projects on larger (urban) scales, and find ways to implement their projects safely and legally by pursuing the necessary administrative, social, technical, financial steps required to create meaningful interventions in public spaces. This class will specifically explore three media for urban intervention: Sound Outdoor video projection Robotics, Autonomy and Mobility in the way of remote control vehicles (e.g. cars, quad-copters, etc.). For each theme, students are required to produce one project that is iterated twice or more. The undergraduate (60441) and graduate (60741) sections of the course meet concurrently and follow the same syllabus and assignments. In addition to the coursework documented in the syllabus, Graduate level students are expected to write a research paper suitable for submission to a notable relevant academic conference. This process includes a rough draft, revisions and a completed and formatted paper ready for submission.

60-446 Advanced SIS: Expanded Theater Fusion Studio

Intermittent: 10 units

[IDeATe collaborative course] As the boundaries between theater, art, entertainment and everyday life continue to expand through engagement with new technologies, it is critical that emerging artists and technologists be provided with the tools, language, and vision to thrive in the new millennium. Expanded Theater will reanimate classical modes of performance with media, networks, robotics, locative applications, and mobile systems. Considering theater as an ancient technology of mass participation and social cohesion, this fusion studio explores how emerging technologies can expand upon the basic theatrical relationships in new and culturally relevant ways. Collaboration and integration of design, media and storytelling is critical to this approach. Experimentation with new forms can reanimate the basic values of theater; the essential nature of a live event, the possibility of visionary spectacle, and the creation of meaning in dialogue with an audience. Expanded Theater is an opportunity to explore avenues outside of traditional theatrical production modes and beyond each student's individual discipline. The curriculum combines resources from Carnegie Mellon's Schools of Art and Drama, Integrative Design, Arts, and Technology (IDeATe), the Emerging Media Masters (EM2), Computer Science, the Robotics Institute, and their collaborators across the university in a new configuration. Expanded Theater will explore domains ranging from site specific and networked-based performance and interventionist practices, to pervasive social media technologies and their influence on interpersonal communication. The goal is to investigate contemporary languages that allow authors, actors and technologists to collaborate in ways that push beyond our present understanding of theatrical production and reception. This course alternates between two modes of research and design.

60-450 Advanced DP3: Drawing

Intermittent: 10 units

Studio focus on drawing experiences designed to develop observational, compositional, technical, expressive, and conceptual skills. Emphasis on independent work, and on the integration of drawing with work in other media.

Prerequisites: 60-150 and (60-151 or 60-160)

60-453 Advanced DP3: Painting

Fall and Spring: 10 units

In this course you will be encouraged to expand your skills and develop a personal vision, while maintaining a spirit of investigation into the developmental process, the magic, the illusion and the physical reality of painting. The professor will act as critic and advisor as students work independently developing self-generated ideas and setting personal goals. We will meet as a class for group critiques, discussions, presentations on the practical aspects of the profession, and slide lectures on contemporary artists.

Prerequisite: 60-250

60-455 Advanced DP3: Intaglio

Intermittent: 10 units

60-455 Advanced PDP: Intaglio. Advanced intaglio studio focuses on the development of additional techniques such as lift and soft grounds, photographic processes, color and multiple plate printing, and viscosity printing. Emphasis will be placed on artistic/image development in relationship to the print as a democratic multiple. In addition cross disciplinary work will be encouraged within other printmaking studios to expand the visual vocabulary and image development.

Prerequisite: 60-251

60-456 Advanced DP3: Lithography

Intermittent: 10 units

Studio focus on the processes and issues of lithographic printmaking. Includes both traditional stone and aluminum plate processes along with photographic techniques.

60-458 Advanced DP3: Serigraphy

Intermittent: 10 units

Advanced PDP: Serigraphy. Studio focus on processes and artmaking issues related to water-based/acrylic serigraphy. Emphasis on individual conceptual/artistic development. Material fee required.

60-462 Advanced DP3: Rethinking Mixed Media & What's Flat

Intermittent: 10 units

This course focuses on your ability to generate ideas and execute a strong and significant body of work in 2D mixed media. As an advanced student you are expected to reach some conclusion about the direction of your work and want to produce and develop your work. Research and experimentation in medium and process is expected along with developing ideas and exploring content and expression. Periodic writing will be required to support your creative research. There is a long history of 2D artists mixing materials and generating more than meets the eye. Materials, process and content will be discussed with emphasis on mixing and integrating orthodox and unorthodox mediums as a way to develop image making that goes beyond the ordinary. Medium process will be discussed but instruction in learning a medium (techniques) will generally not be covered. A variety of critique formats will be maintained weekly along with periodic slide lectures and discussions on artists and critical articles. Where does 2-D end and 3-D begin and have you heard of the talking 2-D work or the 2-D performance, or the flat tube? This course is about engaging in the mixing/combining of 2-D work, including installation, site consideration and other potential mediums.

Prerequisites: 60-150 and 60-250

60-463 Advanced DP3: Print/Draw

Intermittent: 10 units

This course will focus on the development of technical and conceptual strategies in drawing AND/OR print media. With students working in either or both areas, the class the function as a studio workshop in which students set personal goals and strive to produce a significant body of work. Students will be expected to experiment and to create their own problems/limitations, while investigating a range of materials and considering the relationship between form and content. Individual and group critiques will help guide students; presentations on artists, readings, and field trips will contextualize the group's work.

60-464 Advanced DP3: Expanding the Graphic Novel

Intermittent: 10 units

In this course, students will critically and creatively engage the medium of comics to both learn how to better communicate their ideas through this form as well as explore its boundaries. We will investigate the historical roots of comics and of the ?graphic novel? as well as study the structure of a sequential narrative. We will research how various comic artists employ these tools (artists such as, Chris Ware, Alison Bechdel, Lynda Barry, Ivan Brunetti, Michael Deforge, Julia Wertz, Kevin Huizenga, Dash Shaw, Marjane Satrapi etc). Students will also be expected to think beyond the commonly accepted notions of a graphic novel and to question the relevancy of their work in this medium. Finally, students will produce a new body of work that will be compiled and published in a collective anthology.

60-467 Advanced DP3: Printstallation

Intermittent: 10 units

This course offers an expansive approach to print media. It will examine the role of print media in and as installation, addressing the medium in context and as a multiple. Print media, here, is defined as work that may involve traditional practices such as, intaglio, lithography, silkscreen, AND contemporary distribution practices such as ?zines, file sharing and digital imaging. Experimental methods of print production are welcome. Students will generate work to be exhibited, performed or situated for review during individual meetings or group critiques. There will be readings and presentations on contemporary artists, and School of Art Lecture discussions. This course will emphasize student-conceived and executed projects guided by faculty feedback.

Prerequisite: 60-251

60-471 Advanced DP3 Drawing: The Figure, Anatomy and Expression

Intermittent: 10 units

For thousands of years artists have seen the human body as an object of beauty, and as a powerful metaphor for documenting the passion and the paths of human experience. This course will focus on that complex and compelling subject. In class, students will work from the model, studying the figure as a means to heighten sensitivity, expand visual perception, and refine drawing skills. An introduction to the landmarks of anatomical bone and muscle structure will be included. Outside class, students will be encouraged to seek meaning in the humanity of the figure as a vessel for expression, be it personal, social, political, spiritual, narrative or emotional.

60-472 Advanced DP3: Mutable Landscape

Intermittent: 10 units

With camera in hand, students will explore, document and invent a sense of place in Pittsburgh. Informed by photographic history and landscape studies, students will develop their own portfolios of digital prints. As a CFA Interdisciplinary photography course, students will be encouraged to consider their photographs in the medium of their home department, and in some cases as a starting point for projects in other materials. No prerequisites.

60-475 Advanced DP3: Print Media

Intermittent: 10 units

This course offers an inclusive definition of print media that recognizes historical and contemporary tools, techniques and practice. Reproductive image making will be addressed within the context of traditional print media equipment, digital arts output and experimental methods. Essays and lectures on contemporary artists will aid student knowledge of current dialogue and strategies for addressing the printed impression. This course expands upon the theoretical and conceptual themes introduced in Print Media I with emphasis on student-conceived projects led by faculty advising.

Prerequisite: 60-251

60-486 The Art and Science of Color

Intermittent: 10 units

This interdisciplinary course will consist of a combination of chemistry lecture & labs with studio art & art history. The focus of the course will be on the intersection of painting practice with chemistry, particularly in the study of pigments of mineral & inorganic origin. This is a project course open to majors in chemistry & art. The course & its projects are designed to expand the expertise of students in each discipline, while exposing them to the methods, demands, & aims of the other. Historically, the craft of painting was closely linked to the practice of pigment manufacture, with painters procuring their materials in raw form directly from the chemist/apothecary, & often performing themselves the final purification & grinding of the minerals into pigments. Color has been used by both artists & alchemists as a benchmark for tracking changes while creating new materials based on minerals found in nature. With the advent of mass-produced & marketed art materials in the nineteenth century, the distance between chemist & artist increased until the two worlds have little to do with one another. This class aims to reconnect the two disciplines for a study of their common ground. Students will learn about the origin of the color of minerals with primary focus on colors that originate from electronic transitions & will work collaboratively on hands-on laboratory research projects that involve the synthesis, characterization, & use of inorganic pigments. In the studio, they will make their own egg-tempera paints, & use them in painting projects designed to increase color skills as they learn about the history of pigment use. Students will collaboratively design & carry out final projects which combine research, experimentation & creative work. A series of researchers who work at the boundary between art & chemistry will give guest lectures, & the class will make field trips to local research labs & museums.

60-492 Inner Geographies

Intermittent: 10 units

Inner Geographies: On Discovering the Inward Landscapes and Journeys of the Mind and Body This course will discover and explore the inward subconscious topologies of perception, thought (logics), memory, imagination, intuition, the hypnagogic (between dream and waking), dreaming, telepathy, meditation and trance in relation to artistic and other forms of creativity (writing, science, and technologies). The general purpose of the course is to familiarize students with their own unique individual and specific patterns of creativity and thereby reveal new artistic and other unanticipated disciplinary potentials projects. Through simple exercises these aspects of the creative mind and body will be revealed and explored, noted, organized and mapped toward simple formal objects and outcomes, and at the same time, toward a chosen artistic projects or research. All students will evolve a final project. Our texts will include: Anton Ehrensweig, "The Hidden Order of Art", Edward Hall, "The Hidden Dimension", Gaston Bachelard, "The Psychoanalysis of Fire", Carl Gustav Jung, "The Red Book", Martin Heidegger, "Being and Time", and other excerpted texts. Students will be expected to learn, articulate and use new creative mental tools and methodologies in the creation of their projects.

60-499 Studio Independent Study

Fall and Spring

A tutorial studio in which an Art student works individually on a self-generated project under the supervision of a School of Art faculty member. Prior to enrolling in Independent Study, the student must complete an "Independent Study Proposal" form (available in the bins on the 3rd floor of CFA) which is signed by the faculty member and the Assistant Head of the School of Art. Prerequisite: Art Junior/Senior status and by instructor permission.

60-540 The Artist as Entrepreneur

Fall: 3 units

This course is designed for senior (BFA, BHA, BSA and BCSA) and graduate Art students who wish to continue making, showing, and selling work after completing their studies. The focus of this course is on helping students develop the skills and knowledge necessary to establish themselves as working professional artists. Topics include: marketing and promotions, galleries and other exhibition opportunities, pricing work, contracts, taxes and related matters, dealers, grants and other fundraising, other income sources, finding health insurance, and finding and connecting with a community of artists. Students will create professional materials including a resume, business card, promotional post card and mailing list - and will be graded on these materials. There will also be required readings, class speakers and graded journals in response to these activities.

60-590 Internship

Fall and Spring

Art Internships are open to all BFA, BHA, BSA and BCSA Art students. Internships may take place with appropriate individuals or organizations within or outside of Carnegie Mellon University. The requirements for an internship are in the School of Art Handbook (available at the School of Art website). Prior to being enrolled for an internship, students must complete an Internship Proposal Form, which defines the goals of the internship. This form must be signed by their site supervisor and approved by the Assistant Head of the School of Art. Forms are available in the bins on the 3rd floor of CFA. Junior and Senior Art majors only.

60-756 Curators, Artists, Audiences & International Markets

Intermittent: 9 units

How does art and artists get selected for museum shows, collections, and biennials? This course offers students an in-depth view into the multifaceted elements of the markets that influence curators, artists, and audiences. The Global Art Market is a complex structure comprised of many parts and it has been evolving for centuries. The class will provide students with a solid foundation about the history of the art market in order to gain a perspective about the rise and power of the art market today. We will examine who are the current players and operational mechanisms. We will investigate the following: Who are the key players?, Cities?, Collectors?, Professional training? And, investigate Institutions and organizations that influence the acceptance of certain artists, the rise of certain ideologies and the contraction of others. Visits to several institutions, discussions with collectors and auction sites will also occur. An analysis of the 56th Venice Biennale as a point of reference will occur in order to demonstrate why this international show has a particular slant and how the director's point of view influences the selection of artists and themes. Focus will be on the expansion of emerging markets and the influence the art world on line has on artists, curators and audiences.

BXA Intercollege Degree Programs Courses

52-190 BXA Seminar I: Building the Wunderkammer

Fall: 9 units

BXA Seminar I introduces first-year students to the field of interdisciplinary work through the concept of the Wunderkammer, the cabinet of wonders. How do we identify and categorize objects? How do we define their position in the world and in a collection? What kind of knowledge is conveyed through context, representation, and juxtaposition? This class considers how interdisciplinary work can be produced, analyzed, justified, and—most importantly—contextualized. Students engage with theoretical and practical readings from across disciplines, with particular emphasis on interpretive theory. Weekly readings in aesthetic and critical theory introduce students to a particular vocabulary of analysis, practiced in class discussion and written responses. Students will conceive, research, produce, and present a creative final project at the end of the semester.

52-290 Literacy Across Disciplines

Intermittent: 9 units

This course is intended for CFA students who want to improve their writing and communication skills, with a focus on targeting non-specialist audiences. Assignments and readings will cover formats including artists' statements, grant and other funding applications, and other project proposals. Students will also acquire the critical vocabulary to contextualize their creative work in contemporary conversations about the arts. This course will give you the opportunity to develop skills in identifying and targeting audiences in a variety of rhetorical modes and genres. This course is especially well-suited to sophomores and juniors, but is open to all years.

52-291 BXA Seminar II: Building BXA

Spring: 9 units

The goals of BXA Seminar II are twofold: 1) to produce original artwork, research, and event programming that will build visibility and represent the BXA Intercollege Degree Programs to the greater CFA, campus, and regional communities; and 2) to build and strengthen the ties within the BXA community of artist-scholars and foster a greater sense of BXA cohesion. Over the course of the semester, the class will organize the annual BXA Kaleidoscope showing of student creative work; undertake a series of interdisciplinary investigations into the history of BXA; and produce a series of events that will draw in visitors and expose outwards the innovative thinking and making that happen within the three BXA programs. Students will gain experience in interdisciplinary research methods, collaboration, curation, project management, fundraising, and public relations, among other activities. Newly transferred students who are ineligible to take BXA Seminar I should take BXA Seminar II to fulfill this portion of their BXA Seminar requirements.

52-390 BXA Undergraduate Research Project

Fall and Spring

The BXA Undergraduate Research Project is for students who want to work on a self-designed project with the one-to-one guidance of a faculty advisor. The project should be interdisciplinary in nature, and can be a scholarly and/or creative endeavor. The project may take the form of a written thesis, a compilation of creative works, an outreach project, etc. The project topic must be pre-approved by the faculty member who agrees to supervise the project and assign a letter grade for the course. Projects are to be completed in one semester, may be worth 3, 6, 9, or 12 units of academic credit, and cannot be taken concurrently with the BXA Capstone Project during the senior year. To register, students must submit an "Undergraduate Research Project Proposal Form" signed by both the student and the faculty advisor, along with a proposal, to their BXA academic advisor.

52-391 BXA Junior Portfolio

Spring

To better assess the goals and needs of BXA students as they enter their final year and prepare for senior-level projects (e.g. BXA Capstone Project), all students will review their own work and assemble a portfolio during the spring semester of their junior year. Students should work with their BXA advisors and their concentration faculty advisors to assemble a portfolio that represents their academic and creative milestones over the course of their college career. This portfolio also includes reflexive written components to allow students to present a narrative of their history with BXA, and identify their goals, visions, ideas, and concerns for their future work—both for senior year, and beyond. Students should provide an assessment of the areas of intersection between their academic and artistic interests, offer their own specific goals for their academic career, and give a self-evaluation of their performance and opportunities to-date, in light of the programs' broader pedagogical goals.

52-392 BXA Seminar III: Deconstructing Disciplines

Spring: 9 units

The BXA Seminar III will engage BXA juniors in examination of critical theory, the structure of disciplines, and interdisciplinary approaches and methods through analysis of rotating special topics (aesthetic innovation, cultural consumption and production, youth and gender studies, remix, and retrospection). The course will meet weekly, and requirements will include readings, participation in online and seminar discussions, and the production of creative works and formal written analysis in preparation for the BXA Capstone Project.

52-400 BXA Seminar: Capstone

Fall and Spring: 9 units

The BXA Capstone gives BXA students the opportunity to demonstrate the extent of their interdisciplinary work over the course of their academic career. The Capstone should include elements that span the student's CFA and DC concentrations (for BHA students), CFA and MCS concentrations (for BSA students), or CFA and SCS concentrations (for BCSA students). The project can be either a scholarly or creative endeavor, and may take one of many possible forms (e.g., a written thesis, a compilation of creative work or works, an experiment and report, a computer program or animation, etc.). The BXA Capstone sequence covers both semesters of a student's senior year. In the fall, students are enrolled in 52-401 BXA Seminar IV: Capstone Fall (9 units), which meets weekly to discuss strategies for managing research, planning the project, and larger theoretical issues related to interdisciplinary work. At the end of the fall course, students will have produced a Capstone Project proposal, an annotated bibliography, and multiple versions of their project pitch. In the spring, students enroll in 52-402 BXA Seminar: Capstone Spring (9 units), which has no required classroom time. Instead, students spend the semester doing the research and foundational work necessary for the project, as well as meeting with their faculty and BXA advisors as they create their Capstone Project and prepare to present it at the annual Meeting of the Minds Undergraduate Research Symposium held each May. Students will only be enrolled in 52-400 (9 units) when they are unable to complete a two-semester sequence and need to gain special permission by the BXA Director/Academic Advisor.

52-401 BXA Seminar IV: Capstone Fall

Fall: 9 units

The BXA Capstone gives BXA students the opportunity to demonstrate the extent of their interdisciplinary work over the course of their academic career. The Capstone should include elements that span the student's CFA and DC concentrations (for BHA students), CFA and MCS concentrations (for BSA students), or CFA and SCS concentrations (for BCSA students). The project can be either a scholarly or creative endeavor, and may take one of many possible forms (e.g., a written thesis, a compilation of creative work or works, an experiment and report, a computer program or animation, etc.). The BXA Capstone sequence covers both semesters of a student's senior year. In the fall, students are enrolled in 52-401 BXA Seminar IV: Capstone Fall (9 units), which meets weekly to discuss strategies for managing research, planning the project, and larger theoretical issues related to interdisciplinary work. At the end of the fall course, students will have produced a Capstone Project proposal, an annotated bibliography, and multiple versions of their project pitch. In the spring, students enroll in 52-402 BXA Seminar: Capstone Spring (9 units), which has no required classroom time. Instead, students spend the semester doing the research and foundational work necessary for the project, as well as meeting with their faculty and BXA advisors as they create their Capstone Project and prepare to present it at the annual Meeting of the Minds Undergraduate Research Symposium held each May.

52-402 BXA Seminar V: Capstone Spring

Spring: 9 units

The BXA Capstone gives BXA students the opportunity to demonstrate the extent of their interdisciplinary work over the course of their academic career. The Capstone should include elements that span the student's CFA and DC concentrations (for BHA students), CFA and MCS concentrations (for BSA students), or CFA and SCS concentrations (for BCSA students). The project can be either a scholarly or creative endeavor, and may take one of many possible forms (e.g., a written thesis, a compilation of creative work or works, an experiment and report, a computer program or animation, etc.). The BXA Capstone sequence covers both semesters of a student's senior year. In the fall, students are enrolled in 52-401 BXA Seminar IV: Capstone Fall (9 units), which meets weekly to discuss strategies for managing research, planning the project, and larger theoretical issues related to interdisciplinary work. At the end of the fall course, students will have produced a Capstone Project proposal, an annotated bibliography, and multiple versions of their project pitch. In the spring, students enroll in 52-402 BXA Seminar: Capstone Spring (9 units), which has no required classroom time. Instead, students spend the semester doing the research and foundational work necessary for the project, as well as meeting with their faculty and BXA advisors as they create their Capstone Project and prepare to present it at the annual Meeting of the Minds Undergraduate Research Symposium held each May.

52-430 Music of Iran

Fall: 9 units

The Iranian civilization is one of the oldest continuing civilizations in the world. Music has played an important role in the continuation and preservation of this ancient culture. In this course, the traditional, folk, and contemporary music of Iran will be studied and discussed. The focal point of the course will be the Persian modal system, the *Dástgâh*. Starting with a historical survey of the ancient and medieval Persian music, different aspects of the *Dástgâh* system will be demonstrated and discussed. In addition, religious music and folk music of Iran as well as Iranian contemporary music will be discussed during the course.

52-590 BXA Internship

Fall and Spring

An internship is a supervised professional work experience with clear links to a student's academic goals. BXA students may choose to complete a BXA Internship for elective credit with appropriate individuals or organizations within or outside of Carnegie Mellon University. Junior and senior BXA students in good academic standing are eligible to receive academic credit for one internship. Grading is pass/no pass only. Prior to enrolling in an internship, the student must have a "BXA Internship Agreement Form" signed by their site supervisor and approved by their BXA academic advisor.

Biological Sciences Courses**03-050 Study Abroad**

Fall

Missing Course Description - please contact the teaching department.

03-051 Study Abroad

Spring

Missing Course Description - please contact the teaching department.

03-101 Biological Sciences First Year Seminars

Fall and Spring

Various seminars are offered that introduce first-year students to current topics of modern biology. These are mini courses that meet for half a semester. Topics have included: Proteins in Disease, Genes and Diseases, Pills and Poisons, Curing Cancer, Organ Transplantation & Blood Substitutes, and Prions - Mad Cows and Englishman. Courses restricted to first year students in the Mellon College of Science.

03-115 Phage Genomics Research

Fall: 6 units

This course will provide an introduction to biological investigation through a research project in bacteriophage genomics. Genomics combines experimental and computational approaches for large-scale analysis of the biological information contained in DNA sequences. The ability to analyze the complete DNA of any organism has revolutionized modern genetics and is influencing many areas of biology and medicine. The most abundant biological entities are bacteriophages (viruses that infect bacteria). Their enormous diversity and number make bacteriophages important models for the study of gene structure, function and regulation, population genetics and evolution. In addition they are the source of important tools in biotechnology. The research goals of this course will be to identify new bacteriophage species and incorporate them into a comparative genomic study to better understand the genetic organization and evolution of these organisms. While accomplishing these goals students will develop an understanding of the research process, including the ability to design experiments and interpret novel data. Fall semester: Samples will be collected in the field. From these samples students will identify and purify bacteriophages. The bacteriophages will be characterized structurally by electron microscopy, and their DNA will be purified and sequenced. Corequisites: 03-151 and 03-121 and 03-110

03-116 Phage Genomics Research

Spring: 6 units

Spring Semester: The DNA sequences will be analyzed with bioinformatic tools and compared with those of phages isolated at other locations to identify genes, their organization, the differences that may characterize different phage groups, and how these have arisen during evolution. Prerequisite: 03-115

03-121 Modern Biology

All Semesters: 9 units

This is an introductory course that provides the basis for further studies in biochemistry, cell biology, genetics and molecular biology. This course emphasizes the chemical principles underlying biological processes and cell structures as well as the analysis of genetics and heredity from a molecular perspective. This is the introductory biology course for all science and non-science majors.

03-124 Modern Biology Laboratory

Fall and Spring: 9 units

This laboratory is designed to introduce students to modern concepts in the biological sciences. The experiments illustrate many of the principles covered in 03-121 and 03-230. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course. Corequisites: 03-151 and 03-121

03-125 Evolution

Fall: 9 units

Evolutionary theory is the unifying principle of biology. A good comprehension of the concepts that underlie this theory is therefore important to properly appreciate and understand any biological process. This course is designed for students intending to continue studies in biology so that they may gain an understanding of the evolutionary framework in their more advanced courses, and also non-biology majors who want to extend their knowledge of biology at an introductory level. The lectures will include (i) an examination of the history and development of evolutionary theory, (ii) consideration of some of the facts that have established the theory, (iii) an introduction to the concepts of phylogenetics, (iv) discussion of the patterns and mechanism that lead to the diversity and origins of the groups of life, (v) an introduction to genetics and population genetic theory, and (vi) discussion of and how this applies to natural selection and speciation. The course will also include some more specialist topics, including evolution of development, sexual selection, evolutionary applications to medicine and conservation biology, and genome evolution. Assessment will be based on several in-class exams and quizzes, homework assignments, a written term paper, and a final exam.

03-126 Cellular Response to the Environment

Spring: 4 units

This laboratory course provides a multifaceted view of the cell, with the opportunity for new discovery, through microscopic imaging of a cell's response to environmental changes. We will identify yeast gene products that undergo changes in expression or subcellular localization after simple environmental perturbations or drug treatments. Students will be trained in basic molecular biological methods, including recombinant DNA manipulation, and basics of functional genomic resources. Enrollment is limited to first-year students in MCS. Special permission required. Corequisite: 03-121

03-127 How Biological Experiments Work - A Project Course

Spring: 9 units

The goal of this course is to provide an understanding of the nuts and bolts of biological experimentation. We will discuss the molecular principles behind the wide variety of experiments that were used to discover how cells work. The first half of the class will be a lecture based discussion of key experimental methods used in biological research. The second half of the class will be dedicated to group projects that create "story boards" to explain in molecular terms how these experiments work. The story boards will be used by modelers at the Pittsburgh Supercomputing Center to generate high-end animations of these experimental processes. This will prepare students for working in research labs and biology courses beyond "Modern Biology". This course is limited to first, second, and third year students.

Prerequisites: 03-121 and 03-151

03-131 Genes Drugs & Diseases

Fall: 9 units

The central goals of this course are to explore the genetic basis of diseases and to explain the molecular basis of action for various drugs used to treat diseases. The first part of the course provides the student with sufficient background to understand the biological basis of drug action with emphasis on retroviral inhibitors. The usefulness of genetic engineering in the production of proteins for drug discovery is then explored. This is followed by an overview of DNA replication, transcription, and protein synthesis, with an emphasis on the inhibitory action of antibiotics on prokaryotic processes. The fundamental properties of carbohydrates, lipids, and membranes are discussed at a level to develop an understanding of penicillin and the treatment of elevated cholesterol levels. Signaling processes in eukaryotic cells is discussed with reference to cancer treatment and pain management. The treatment of disease using antibody, and the treatment of inappropriate immune responses (allergy) is also discussed. The course ends with a discussion of inheritance and genetic deficiencies that give rise to disease.

03-132 Basic Science to Modern Medicine

Fall: 9 units

This course will focus on the genetics, cell biology, and developmental biology behind human biology and human disease, as well as the growing opportunities for novel therapeutic options that basic science delivers. This is a topics based course, with topics chosen to cover aspects of human biology and health that students are likely to encounter in their daily lives such as cancer, stem cells, genome sequencing, and the human microbiota. Students will explore these topics from both a basic science and a human health perspective.

03-151 Honors Modern Biology

Fall: 10 units

This course will cover in some depth, the basics of the structure and function of the major biomolecules in the cell, cellular structure and function, genetic replication, transmission and expression of biological information, and cell-cell interactions. While similar core topics will be covered in all sections of Modern Biology, this section will be offered at an accelerated pace, requiring more independent learning. The extra class time this pacing provides will allow the exploration of the molecular basis of life to help students integrate and apply the core principles of biology covered in the course. THIS SECTION IS RESERVED FOR INCOMING FIRST-YEAR MCS STUDENTS.

03-161 Molecules to Mind

Spring: 9 units

This course provides a depth-first approach to understanding neuroscience. We will begin with a clinical focus on neuroanatomy, introducing students to some basic neurological diagnostic techniques. We will then explore the biological basis of neuronal function and link the function of individual neurons to a broader context of neural systems. This will be done in the context of primary literature. Students who complete this course will therefore have an understanding of research methods and be prepared to evaluate scientific literature. The course will have a strong focus on the biological and cellular basis of neuronal excitability and also give students significant, in depth exposure to the function of synapses and their plasticity. Finally, the course will give students an in depth look at sensory and/or motor systems by focusing on one system in particular, rather than providing a broad overview of many different sensory and motor systems.

03-201 Undergraduate Colloquium for Sophomores

Fall

The purpose of this seminar series is to update biology undergraduates about university and departmental functions, seminars, etc. that are pertinent or useful. In addition, research talks by faculty and undergraduates will be used to introduce students to the research being conducted in faculty laboratories. Additional topics may include graduate and medical school applications, career options, topics in the press, and important scientific discoveries.

03-202 Undergraduate Colloquium for Sophomores

Spring

Missing Course Description - please contact the teaching department.

03-206 Biomedical Engineering Laboratory

Fall and Spring: 9 units

This laboratory course is designed to provide students with the ability to make measurements on and interpret data from living systems. The experimental modules reinforce concepts from 42-101 Introduction to Biomedical Engineering and expose students to four areas of biomedical engineering: biomedical signal and image processing, biomaterials, biomechanics, and cellular and molecular biotechnology. Several cross-cutting modules are included as well. The course includes weekly lectures to complement the experimental component. Prerequisites: 42-101 Introduction to Biomedical Engineering and 03-121 Modern Biology. Priority for enrollment will be given to students who have declared the Additional Major in Biomedical Engineering. Notes: This course number is reserved for students registered with the HPP program that, are CIT majors. If you require a biology lab for pre-health admissions requirements, please contact Dr. Conrad Zapanta and Dr. Maggie Braun (in the same email) for permission to register for 03-206 instead of 42-203. Priority for enrollment will be given to students who have declared the Additional Major in Biomedical Engineering.

Prerequisites: (03-121 or 03-151) and 42-101

03-210 Independent Study

Fall and Spring

Students will read papers from the original literature under the direction of a faculty member. Students will be required to demonstrate mastery of the readings by discussions with the sponsoring faculty member, oral presentations, or writing of one or more papers summarizing and extending the information in the readings. If appropriate, students may write a program(s) to satisfy this last requirement. A student may take this course only once. This is a mini format course. Special permission required.

03-230 Intro to Mammalian Physiology

Spring: 9 units

This course will survey the major organ systems, with an emphasis on cellular physiology and biochemistry. Current ideas of research and scientific controversy will also be presented. This course is intended to broaden students' exposure to cellular processes in the context of complex organ systems.

Corequisite: 03-121

03-231 Biochemistry I

Fall: 9 units

This course provides an introduction to molecules and processes found in living systems. Amino acids, sugars, lipids and nucleotides and their corresponding higher structures, the proteins, polysaccharides, membranes and nucleic acids are studied. Kinetics and mechanisms of enzymes as well as elementary metabolic cycles and the energetics of biological systems are discussed.

Corequisite: 09-217

03-232 Biochemistry I

Spring: 9 units

This course provides an introduction to the application of biochemistry to biotechnology. The functional properties of amino acids, nucleotides, lipids, and sugars are presented. This is followed by a discussion of the structural and thermodynamic aspects of the organization of these molecules into higher-order structures, such as proteins, nucleic acids, and membranes. The kinetics and thermodynamics of protein-ligand interactions are discussed for non-cooperative, cooperative, and allosteric binding events. The use of mechanistic and kinetic information in enzyme characterization and drug discovery are discussed. Topics pertinent to biotechnology include: antibody production and use, energy production in biochemical systems, expression of recombinant proteins, and methods of protein purification and characterization. The course is an alternate to 03-231.

Prerequisites: 09-217 or 09-219

Corequisites: 09-106 or 06-221

03-240 Cell Biology

Spring: 9 units

This course provides descriptive information and mechanistic detail concerning key cellular processes in six areas: membrane function, protein targeting, signaling, cytoskeleton, cell division, and cell interaction. An attempt is made to introduce the methodology that was used to obtain this information and to discuss how our understanding of these processes relates to the treatment of human disease.

Prerequisites: (03-120 or 03-121) and (03-231 or 03-232 or 03-233)

03-250 Introduction to Computational Biology

Spring: 12 units

This class provides a general introduction to computational tools for biology. The course is divided into two modules, which may be taken individually as courses 03-251/02-251 and 03-252/02-252. Module 1 covers computational molecular biology/genomics. It examines important sources of biological data, how they are archived and made available to researchers, and what computational tools are available to use them effectively in research. In the process, it covers basic concepts in statistics, mathematics, and computer science needed to effectively use these resources and understand their results. Specific topics covered include sequence data, searching and alignment, structural data, genome sequencing, genome analysis, genetic variation, gene and protein expression, and biological networks and pathways. Module 2 covers computational cell biology, including biological modeling and image analysis. It includes homeworks requiring use or modification of Matlab scripts. The modeling component includes computer models of population dynamics, biochemical kinetics, cell pathways, neuron behavior, and stochastic simulations. The imaging component includes basics of machine vision, morphological image analysis, image classification and image-derived models. Lectures and examinations are joint with 02-250 but recitations are separate. Recitations for this course are intended primarily for biological sciences or biomedical engineering majors at the undergraduate or graduate level who have had little or no prior experience with computer science or programming. Students may not take both 03-250/02-250 and either 03-251/02-251 or 03-252/02-252 for credit. Prerequisite: 03-121 or permission of the instructors. Prerequisites: 03-120 or 03-121 or 03-151 or 03-131

03-251 Introduction to Computational Molecular Biology

Spring: 6 units

This class provides a general introduction to computational tools for biology with specific emphasis on molecular biology and genomics. Along with 03-252, it makes up one half of the full Introduction to Computational Biology, 03-250, although either half can be taken individually. 03-251 will examine important sources of biological data, how they are archived and made available to researchers, and what computational tools are available to use them effectively in research. In the process, it will cover basic concepts in statistics, mathematics, and computer science needed to effectively use these resources and understand their results. Specific topics to be covered include sequence data, searching and alignment, structural data, genome sequencing, genome analysis, genetic variation, gene and protein expression, and biological networks and pathways. Lectures and examinations are joint with 02-251 but recitations are separate. Recitations for this course are intended primarily for biological sciences or biomedical engineering majors at the undergraduate or graduate level who have had little or no prior experience with computer science or programming. Students may not take both 03-251/02-251 and 03-250/02-250 for credit. Prerequisite: 03-121 or permission of the instructor. Prerequisites: 03-121 and 03-151

03-252 Introduction to Computational Cell Biology

Spring: 6 units

This course presents an overview of important modeling and image analysis applications of computers to solve problems in cell biology. Along with 03-251, it makes up one half of the full Introduction to Computational Biology, 03-250, although either half can be taken individually. Major topics covered are computer models of population dynamics, biochemical kinetics, cell pathways, neuron behavior, and stochastic simulations. The imaging component includes basics of machine vision, morphological image analysis, image classification and image-derived models. It includes homeworks requiring use or modification of Matlab scripts. Lectures and examinations are joint with 02-252 but recitations are separate. Recitations for this course are intended primarily for biological sciences or biomedical engineering majors at the undergraduate or graduate level who have had little or no prior experience with computer science or programming. Students may not take both 03-252/02-252 and 03-250/02-250 for credit. Prerequisite: 03-121 or permission of the instructor. Prerequisites: 03-121 and 03-151

03-260 Neurobiology of Disease

Fall: 9 units

This course will explore the biological basis of several neurological and neuropsychiatric diseases, with an emphasis on medical diagnostic tools and techniques. It will include discussions of the anatomical basis of neurological diseases as well as recent research into understanding the mechanisms of disease. This course is intended to broaden students' understanding of how diseases are diagnosed and studied. Students will also learn how basic neurological and psychiatric evaluations are conducted and gain proficiency in these evaluation techniques. We will begin with a discussion of clinical neuroanatomy to serve as a basis for understanding brain structures and functional alterations in a variety of developmental, degenerative, neurological, and psychiatric disorders. Specific diseases covered may vary from year to year. Prerequisites: 03-121 or 03-151 or 03-161 or 85-219

03-301 Undergraduate Colloquium for Juniors

Fall

The purpose of this seminar series is to update biology undergraduates about university and departmental functions, seminars, etc. that are pertinent or useful. In addition, research talks by faculty and undergraduates will be used to introduce students to the research being conducted in faculty laboratories. Additional topics may include graduate and medical school applications, career options, topics in the press, and important scientific discoveries.

03-302 Undergraduate Colloquium for Juniors

Spring

Missing Course Description - please contact the teaching department.

03-326 Evolution of Regulatory Genomics

Fall: 4.5 units

This course will examine the processes by which genomes evolve and how this genetic variation leads to phenotypic diversity. An introduction to gene regulation, how the genome controls development, comparisons of development and the phenotypic diversity in animals will be provided. Then we will consider ways in which genomes evolve, followed by in-depth coverage of how gene regulation has evolved (focusing on cis regulatory evolution and non-coding RNA regulatory evolution). Finally the concept of gene regulatory network control of development and understanding evolution as change in these networks will be examined. Concepts and specific examples will come through reading of primary literature and selected readings from advanced texts. Prerequisite: 03-231

Corequisite: 03-330

03-327 Phylogenetics

Fall: 9 units

An advanced introduction to theory and practice of phylogenetic analysis (evolutionary tree reconstruction), with a focus on molecular evolution. Basic concepts will be introduced in the context of a historical survey of phylogeny reconstruction. A comprehensive introduction to phylogenetic methods will be presented, including data selection, multiple sequence alignment, character state data versus distance matrices, sequence evolution models, and the four major approaches to phylogeny reconstruction: Parsimony, Distance matrix, Maximum likelihood, and Bayesian analysis. Sources of error and methods for assessing the reliability of phylogenetic inference will be discussed. We will cover additional topics as time allows, such as phylogenetic hypothesis testing, genome scale approaches, the interface between phylogenetics and population genetics, gene tree reconciliation, horizontal gene transfer, and phylogenetic networks. Prerequisites: 03-231 or 03-250 or 03-232

03-330 Genetics

Fall: 9 units

The mechanisms of transmission of inherited traits in viruses, bacteria, fungi, plants and animals are discussed. Molecular mechanisms of gene expression and gene regulation are analyzed. Recombinant DNA and its applications in genetic analysis, biotechnology, forensics, agriculture, medicine, and the pharmaceutical industry are presented. Special topics in human genetics are considered, such as the genetics of cancer. Principles and methods for the study of developmental genetics, population genetics and complex traits are also introduced. Prerequisites: 03-151 or 03-121

03-342 Introduction to Biological Laboratory Practices

Fall: 1 unit

This course is designed for students in the BS in Computational Biology degree program. It is a required co-requisite for 03-343, Experimental Genetics and Molecular Biology and is designed to be an introduction to basic laboratory practices. The course will introduce biological and chemical safety training and basic laboratory practices. Techniques of solution preparation and titration, pipetting, UV/VIS spectroscopy, and quantitation of biological compounds will be covered.

Corequisite: 03-343

03-343 Experimental Techniques in Molecular Biology

Fall: 12 units

This laboratory course is designed to teach experimental methods of modern biology. Experiments in microbial genetics, molecular biology and eukaryotic genetics are performed. Emphasis is placed on understanding and applying the biological principles of each experiment. This course is designed to be taken during the junior year and is intended to prepare students for undergraduate research. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course.

Prerequisites: (03-231 or 03-232) and 09-222

Corequisite: 03-330

03-344 Experimental Biochemistry

Spring: 12 units

This course is designed to be taken as a sequel to 03-343. Experiments cover a variety of methods for investigating the structure and function of biological molecules. Experimental methods with proteins, enzyme kinetics, lipids, spectroscopy, and isolation and quantization of biological molecules are covered. During several experiments, students design their own projects. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course.

Prerequisites: 03-343 and (03-231 or 03-232)

03-345 Experimental Cell and Developmental Biology

Intermittent: 12 units

This laboratory is designed to teach concepts and experimental methods in cell and developmental biology. Students work with a variety of organisms to examine how cells traverse development from rapidly dividing, undifferentiated cells, through cell commitment and the establishment of spatial and temporal patterns of gene expression, to the specific characteristics and responses of terminally differentiated cells. The course makes extensive use of video microscopy with phase contrast, DIC and fluorescence microscopes. Biochemical, immunological and molecular biological techniques are used to probe the molecules and processes of cells undergoing development. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course.

Prerequisites: 03-343 and (03-231 or 03-232) and 03-240 and 03-330

Corequisite: 03-350

03-346 Experimental Neuroscience

Intermittent: 12 units

This laboratory is designed to teach concepts and experimental methods in neurobiology. Students work with a variety of organisms to study the anatomy, function, and development of the nervous system. Immunological, molecular, biochemical, and ballistic labeling techniques are used to examine the gene expression and structure in the mature and developing nervous system. Students study the function of neurons through neurophysiological techniques in invertebrates and computer simulation. This course makes extensive use of video microscopy and phase contrast, DIC, and fluorescence microscopes.

Prerequisites: 03-240 and 03-343 and 03-362

03-350 Developmental Biology

Spring: 9 units

How does a complex, multicellular organism arise from a single cell? How do cells with identical genomes acquire distinctive properties? What are the medical consequences of abnormal embryonic development? How does regeneration occur? How has evolution modified developmental programs to produce different body plans? These are some of the central questions in the field of developmental biology. This course serves as an introduction to current concepts and experimental approaches in this rapidly advancing field. Topics in the course include genomics, differential gene expression, cell signaling, cell movements, tissue morphogenesis, stem cells, human development, and regeneration. The course examines the genes and signaling pathways that control development and the role that mis-regulation of these pathways plays in human disease.

Prerequisite: 03-240

03-362 Cellular Neuroscience

Fall: 9 units

Modern neuroscience is an interdisciplinary field that seeks to understand the function of the brain and nervous system. This course provides a comprehensive survey of cellular and molecular neuroscience ranging from molecules to simple neural circuits. Topics covered will include the properties of biological membranes, the electrical properties of neurons, neural communication and synaptic transmission, mechanisms of brain plasticity and the analysis of simple neural circuits. In addition to providing information the lectures will describe how discoveries were made and will develop students' abilities to design experiments and interpret data.

Prerequisites: 03-240 or 42-202 or 03-161 or 85-219

03-363 Systems Neuroscience

Spring: 9 units

Modern neuroscience is an interdisciplinary field that seeks to understand the function of the brain and nervous system. This course provides a comprehensive survey of systems neuroscience, a rapidly growing scientific field that seeks to link the structure and function of brain circuitry to perception and behavior. This course will explore brain systems through a combination of classical, Nobel prize-winning data and cutting edge primary literature. Topics will include sensory systems, motor function, animal behavior and human behavior in health and disease. Lectures will provide fundamental information as well as a detailed understanding of experimental designs that enabled discoveries. Finally, students will learn to interpret and critique the diverse and multimodal data that drives systems neuroscience.

Prerequisites: 03-161 or 03-240 or 42-202 or 85-219

03-364 Developmental Neuroscience

Fall: 9 units

This course examines the principles that govern the developmental assembly of a complex nervous system. Topics range from the earliest steps of induction of neural tissue and birth of neurons to the plasticity within developing circuits and the development of behavior. By the end of this course students should be able to describe the major steps in neural development and to interpret key experiments using vertebrate and invertebrate models have helped to elucidate these steps. This course is taught on the University of Pittsburgh campus by faculty from Carnegie Mellon and Pitt.

Prerequisites: 03-240 or 03-362 or 03-363

03-365 Neural Correlates of Learning and Memory

Spring: 9 units

Neural plasticity underlies the capacity of the central nervous system to encode new information, develop new abilities, and adapt to the environment. This course will examine the latest advances in defining biological substrates of learning, memory, and behavioral adaptation. Topics covered will include structural and functional plasticity of individual neurons, learning-induced changes in emergent circuit properties, and substrates of learning vulnerable to disease.

Prerequisites: 03-362 or 03-363

03-370 Principles of Biotechnology

Spring: 9 units

This course is intended to provide an introduction to a set of core areas important for understanding and managing biotechnology business. Essentially, the focus of the course will be the basics of the biotechnology entrepreneurial process and a deep background on biotechnology enabled products. The objective is to provide the background for management-level personnel to make decisions based on knowledge of contemporary biotechnologies and the legal and regulatory environment. Because it is impossible to be comprehensive with regard to all applications, the goal is to provide students with sufficient familiarity with current biotechnology and with a framework for assessing bio-related business questions that they may encounter in the future through a combination of independent research, assessment of opportunities and pitfalls, and historical comparisons. NOTE: This course CANNOT be counted towards the advanced biology electives for any major or minor in Biological Sciences.

Prerequisites: (03-231 or 03-232) and 03-240

03-390 Molecular and Cellular Immunology

Spring; 9 units

This course offers the student a comprehensive view of modern immunology at the molecular and cellular level. The first half of the course presents the fundamentals of immunology, beginning with innate immunity, followed by a discussion of the structure and function of important molecules in the immune system, such as antibodies, major histocompatibility antigens, complement, and the T-cell receptor. This portion of the course is concluded with a discussion of the development and function of the cellular immune response. The second half of the course is focused on applied immunology and discusses hypersensitivity, autoimmunity, immunodeficiencies, tumor immunology, infectious disease, and transplantation immunology. Presentations at the end of the course provide an opportunity for the student to explore additional topics in contemporary immunology.

Prerequisites: (03-231 or 03-232) and 03-240

03-391 Microbiology

Spring; 9 units

The course provides introductory level molecular biology that is aimed for students from all disciplines of natural science. It covers microbiology, genetics, genomics and virology, as well as related biophysics of RNA and DNA packaging, protein self-assembly and molecular motors. We also review the latest biophysical methods with a focus on single molecule techniques that have revolutionized the biological sciences.

Prerequisites: 03-231 or 03-232

03-392 Microbiology Laboratory

Intermittent; 6 units

This is an upper level biology course for students who have taken or are currently taking the Microbiology course and are interested in laboratory experience in microbiology. It is designed with the recommendations of the American Society for Microbiology for a student laboratory course in mind in order to introduce the student to a broad spectrum of techniques in microbiology. You will learn the skills needed to perform experiments that help to differentiate various types of microbes, examine antimicrobial and antibiotic sensitivity and resistance, and begin to explore microbial diversity. Finally, you will develop an understanding of the theory behind the techniques you use and will be given the opportunity to further develop your skills in the process of experimental design. THIS COURSE WILL BE OFFERED EVERY OTHER SPRING, BEGINNING IN THE SPRING 2017 (NOT offered spring 2016).

Corequisite: 03-391

03-401 Undergraduate Colloquium for Seniors

Fall

The purpose of this seminar series is to update biology undergraduates about university and departmental functions, seminars, etc. that are pertinent or useful. In addition, research talks by faculty and undergraduates will be used to introduce students to the research being conducted in faculty laboratories. Additional topics may include graduate and medical school applications, career options, topics in the press, and important scientific discoveries.

03-402 Undergraduate Colloquium for Seniors

Spring

Missing Course Description - please contact the teaching department.

03-409 Special Topics

Intermittent; 9 units

Note: This class is available only on the Qatar campus. This course covers the progress of stem cell research and its application to tissue engineering and regenerative therapy. This is an advanced Biology elective. The students will learn about the different types of stem cells, the biochemical stimuli that are responsible for regulating stem cell differentiation and techniques involved in the culture of stem cells. This subject will also highlight the development of various biomaterials that are used as biological substitutes in regenerative therapy. Current and emergent stem cell technologies in selected applications of tissue engineering in bone, skin and vascular tissues will be emphasized. The course will be delivered through problem-based learning where students are expected to participate in discussions, perform literature search, present their findings through presentations and written reports on selected topics. The class is designed for upper undergraduates with a strong interest in stem cell biology, and the desire to actively contribute to discussions in the class.

Prerequisite: 03-240

03-410 Special Topics in Biological Sciences

Fall and Spring

Special Topics in Biological Sciences. Topics will vary depending on the semester and instructor. Please read the individual section descriptions for more information.

Prerequisite: 03-240

03-411 Topics in Research

Fall

During the year students attend and submit brief summaries of weekly seminars given by outside speakers or members of the Biology Department on current research topics in modern biology; some seminars outside of the department may be substituted.

03-412 Topics in Research

Spring

During the year students attend and submit brief summaries of weekly seminars given by outside speakers or members of the Biology Department on current research topics in modern biology. Some seminars outside of the department may be substituted.

03-439 Introduction to Biophysics

Fall; 9 units

This intermediate level course is primarily offered to Physics and Biology undergrads (junior/senior) and provides a modern view of molecular and cellular biology as seen from the perspective of physics, and quantified through the analytical tools of physics. This course will not review experimental biophysical techniques (which are covered, e.g., in 03-871). Rather, physicists will learn what sets "bio" apart from the remainder of the physics world and how the apparent dilemma that the existence of life represents to classical thermodynamics is reconciled. They also will learn the nomenclature used in molecular biology. In turn, biologists will obtain (a glimpse of) what quantitative tools can achieve beyond the mere collecting and archiving of facts in a universe of observations: By devising models, non-obvious quantitative predictions are derived which can be experimentally tested and may lead to threads that connect vastly different, apparently unrelated phenomena. One major goal is then to merge the two areas, physics and biology, in a unified perspective.

Prerequisites: 03-231 or 03-232

Course Website: <http://www.cmu.edu/smsl/teaching/IntroBioPhys.html>**03-442 Molecular Biology**

Fall; 9 units

The structure and expression of eukaryotic genes are discussed, focusing on model systems from a variety of organisms including yeast, flies, worms, mice, humans, and plants. Topics discussed include (1) genomics, proteomics, and functional proteomics and (2) control of gene expression at the level of transcription of mRNA from DNA, splicing of pre-mRNA, export of spliced mRNA from the nucleus to the cytoplasm, and translation of mRNA.

Prerequisite: 03-330

03-445 Undergraduate Research

Fall and Spring

Students may investigate research problems under the supervision of members of the faculty. Permission of a faculty advisor required.

03-451 Advanced Developmental Biology and Human Health

Fall; 9 units

This course will examine current research in developmental biology, focusing on areas that have important biomedical implications. The course will examine stem cell biology, cellular reprogramming, cell signaling pathways, tissue morphogenesis, and genetic/developmental mechanisms of birth defects and human diseases. Emphasis will be placed on the critical reading of recent, original research papers and classroom discussion, with supporting lectures by faculty.

Prerequisites: 03-330 and 03-240

03-511 Computational Molecular Biology and Genomics

Fall; 9 units

An advanced introduction to computational molecular biology, using an applied algorithms approach. The first part of the course will cover established algorithmic methods, including pairwise sequence alignment and dynamic programming, multiple sequence alignment, fast database search heuristics, hidden Markov models for molecular motifs and phylogeny reconstruction. The second part of the course will explore emerging computational problems driven by the newest genomic research. Course work includes four to six problem sets, one midterm and final exam.

Prerequisites: (03-151 or 03-121) and 15-122

Course Website: <http://www.cs.cmu.edu/~durand/03-711/>

03-512 Computational Methods for Biological Modeling and Simulation

Fall: 9 units

This course covers a variety of computational methods important for modeling and simulation of biological systems. It is intended for graduates and advanced undergraduates with either biological or computational backgrounds who are interested in developing computer models and simulations of biological systems. The course will emphasize practical algorithms and algorithm design methods drawn from various disciplines of computer science and applied mathematics that are useful in biological applications. The general topics covered will be models for optimization problems, simulation and sampling, and parameter tuning. Course work will include problems sets with significant programming components and independent or group final projects.

Prerequisites: (03-121 or 03-151) and 15-122

03-534 Biological Imaging and Fluorescence Spectroscopy

Fall: 9 units

This course covers principles and applications of optical methods in the study of structure and function in biological systems. Topics to be covered include: absorption and fluorescence spectroscopy; interaction of light with biological molecules, cells, and systems; design of fluorescent probes and optical biosensor molecules; genetically expressible optical probes; photochemistry; optics and image formation; transmitted-light and fluorescence microscope systems; laser-based systems; scanning microscopes; electronic detectors and cameras; image processing; multi-mode imaging systems; microscopy of living cells; and the optical detection of membrane potential, molecular assembly, transcription, enzyme activity, and the action of molecular motors. This course is particularly aimed at students in science and engineering interested in gaining in-depth knowledge of modern light microscopy.

Prerequisites: (03-231 or 03-232) and 03-240 and 21-259 and (09-214 or 09-344)

03-545 Honors Research

Spring

This semester of research consists primarily of research and preparation of an acceptable written thesis. Oral presentation and defense of the thesis research will be required. This course ordinarily will be taken in the second semester of the senior year. Permission of the research advisor required.

Prerequisite: 03-445

03-601 Computational Biology Internship

All Semesters

This course allows a student to gain computational biology experience in a "real-world" setting. Internships vary widely in scope, but common to all is the chance to practice computational biology skills acquired in the classroom. Typically, students seek and secure their own internships.

03-620 Techniques in Electron Microscopy

Spring: 9 units

This course is designed to teach basic methods in transmission electron microscopy to graduate and undergraduate students. Sophomores with an interest in electron microscopy are encouraged to enroll, and will have the option and opportunity to utilize their skills in various laboratories during their junior or senior year. The course will be offered once each year, during the spring semester. Course enrollment will be limited to 4-6 students. Preferential enrollment will be given to graduate students and undergraduate students who have demonstrated a need for this technique in their research. The class will include one hour of lecture and 4 hours of laboratory each week (some additional laboratory time outside of the scheduled laboratory time is required). Students will learn basic methods in specimen preparation for both transmission and scanning electron microscopy (fixation, embedding and ultramicrotomy, drying and metal coating) and will be trained in the operation of both the Hitachi 7100 and 2460N electron microscopes. Lectures and laboratories during the last few weeks of the semester will introduce the students to special techniques (e.g. immunoelectron microscopy, cryoultramicrotomy, freeze substitution, variable pressure SEM, etc.) and will allow them to work with samples from their own research. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course. Special permission is required.

03-700 MS Thesis Research

All Semesters

A student enrolled in this course conducts an independent investigation on a project in a faculty advisor's lab. The project is selected from a major area of research study with the advice and approval of the faculty advisor. This course is required of students who are enrolled in the Master of Science program and wish to write and defend a thesis.

03-709 Applied Cell and Molecular Biology

Fall: 12 units

The purpose of this course is to review key cellular and molecular phenomenon in biological pathways with strong emphasis on latest experimental techniques used in applications including but not limited to disease diagnosis, therapeutics, large-scale genomic and proteomic analysis. Knowledge gained from this course will be both conceptual and analytical. Students will periodically write extensive research reports on select topics and give oral presentations on a select few, while critically analyzing primary literature.

03-710 Computational Biology

Spring: 12 units

This course covers a range of applications of computers to solve problems in biology and medicine. Specific topics covered are computational molecular biology (analysis of protein and nucleic acid sequences), biological modeling and simulation (including computer models of neuron behavior, biochemical kinetics, and simulation of mutation), and biological imaging. Course work will include use of software packages for these applications, reading of scientific papers, and programming assignments. Students may use one of the following courses for credit, 03-310, 03-311, 03-510 or 03-710.

Prerequisites: 03-121 and (15-200 or 15-211)

03-711 Computational Molecular Biology and Genomics

Fall: 12 units

An advanced introduction to computational molecular biology, using an applied algorithms approach. The first part of the course will cover established algorithmic methods, including pairwise sequence alignment and dynamic programming, multiple sequence alignment, fast database search heuristics, hidden Markov models for molecular motifs and phylogeny reconstruction. The second part of the course will explore emerging computational problems driven by the newest genomic research. Course work includes four to six problem sets, one midterm and final exam.

Prerequisites: (03-121 or 03-151) and 15-122

Course Website: <http://www-2.cs.cmu.edu/~durand/03-711/>**03-712 Computational Methods for Biological Modeling and Simulation**

Spring: 12 units

This course covers a variety of computational methods important for modeling and simulation of biological systems. It is intended for graduates and advanced undergraduates with either biological or computational backgrounds who are interested in developing computer models and simulations of biological systems. The course will emphasize practical algorithms and algorithm design methods drawn from various disciplines of computer science and applied mathematics that are useful in biological applications. The general topics covered will be models for optimization problems, simulation and sampling, and parameter tuning. Course work will include problems sets with significant programming components and independent or group final projects.

Prerequisites: (03-121 or 03-151) and 15-122

03-713 Bioinformatics Data Integration Practicum

Spring: 6 units

Missing Course Description - please contact the teaching department.

03-726 Evolution of Regulatory Genomics

Fall: 6 units

This course will examine the processes by which genomes evolve and how this genetic variation leads to phenotypic diversity. An introduction to gene regulation, how the genome controls development, comparisons of development and the phenotypic diversity in animals will be provided. Then we will consider ways in which genomes evolve, followed by in depth coverage of how gene regulation has evolved (focusing on cis regulatory evolution and non-coding RNA regulatory evolution). Finally the concept of gene regulatory network control of development and understanding evolution as change in these networks will be examined. Concepts and specific examples will come through reading of primary literature and selected readings from advanced texts. Grading will be based on written assignments from readings of literature, participation in class discussion, and two in class exams. The graduate level course (03-726) will in addition require a term paper based on thorough and critical reading of primary literature focused on one of the general topics presented in the course.

Corequisite: 03-330

03-727 Phylogenetics

Fall: 12 units

An advanced introduction to theory and practice of phylogenetic analysis (evolutionary tree reconstruction), with a focus on molecular evolution. Basic concepts will be introduced in the context of a historical survey of phylogeny reconstruction. A comprehensive introduction to phylogenetic methods will be presented, including data selection, multiple sequence alignment, character state data versus distance matrices, sequence evolution models, and the four major approaches to phylogeny reconstruction: Parsimony, Distance matrix, Maximum likelihood, and Bayesian analysis. Sources of error and methods for assessing the reliability of phylogenetic inference will be discussed. We will cover additional topics as time allows, such as phylogenetic hypothesis testing, genome scale approaches, the interface between phylogenetics and population genetics, gene tree reconciliation, horizontal gene transfer, and phylogenetic networks. Course work will include readings from textbooks and seminal articles from the primary literature, problem sets, a final exam and possibly in class exams. Students in 03-727 will also carry out a major data analysis project, intended to familiarize the student with the practical application of principles taught in class. A short paper summarizing the results of this project will be required.

03-730 Advanced Genetics

Spring: 12 units

This course considers selected current topics in genetics at an advanced level. Emphasis is on classroom discussion of research papers. Topics change yearly. Recent topics have included nucleocytoplasmic trafficking of RNA in yeast, genome imprinting in mammals, genetics of learning and memory in *Drosophila*, and viral genomics.

Prerequisites: 03-330 and (03-442 or 03-742)

03-740 Advanced Biochemistry

Spring: 12 units

This is a special topics course in which selected topics in biochemistry will be analyzed in depth with emphasis on class discussion of papers from the recent research literature. Topics change yearly. Recent topics have included single molecule analysis of catalysis and conformational changes; intrinsically disordered proteins; cooperative interactions of aspartate transcarbamoylase; and the mechanism of ribosomal protein synthesis.

03-741 Advanced Cell Biology

Spring: 12 units

This course covers fourteen topics in which significant recent advances or controversies have been reported. For each topic there is a background lecture by the instructor, student presentations of the relevant primary research articles and a general class discussion. Example topics are: extracellular matrix control of normal and cancer cell cycles, force generating mechanisms in trans-membrane protein translocation, signal transduction control of cell motility, and a molecular mechanism for membrane fusion.

Prerequisites: 03-240 and (03-231 or 03-232)

03-742 Molecular Biology

Fall: 12 units

The structure and expression of eukaryotic genes are discussed, focusing on model systems from a variety of organisms including yeast, flies, worms, mice, humans, and plants. Topics discussed include (1) genomics, proteomics, and functional proteomics and (2) control of gene expression at the level of transcription of mRNA from DNA, splicing of pre-mRNA, export of spliced mRNA from the nucleus to the cytoplasm, and translation of mRNA.

Prerequisite: 03-330

03-744 Membrane Trafficking

Spring: 9 units

While the focus of this course is to analyze membrane/protein traffic along both the biosynthetic and endocytic pathways, our general goal is to teach students how to read and interpret the literature. In particular, we emphasize the conclusions and discuss their validity. The course is updated each year to include topics in which new and interesting developments have occurred. Emphasis is placed on how membrane traffic is regulated and where applicable how it is disrupted or subverted during disease processes. The course is of general interest to students, fellows, and faculty interested in cell biology, immunology, neurobiology, pharmacology and virology.

Prerequisite: 03-240

03-745 Core Course in Biochemistry

Fall: 6 units

This course is designed to provide first year doctoral students in the Department of Biological Sciences with a broad foundation in biochemistry and biophysical techniques. Topics include protein structure, enzymology, and methods to characterize protein structure and function. Students will be evaluated throughout the course, and with a final exam.

03-746 Core Course in Cell Biology

Fall: 6 units

This course is designed to provide first year doctoral students in the Department of Biological Sciences with a broad foundation in cell biology. Topics include, but are not limited to, intracellular trafficking, signal transduction, the cytoskeleton, the cell cycle, and cell-cell interactions. This is a lecture-based course and will include some discussion of the primary literature. Students will be evaluated weekly, and with a final exam. Enrollment requires instructor permission.

03-747 Proposal Preparation and Peer Review

Fall: 4 units

The concise and clear presentation of an experimental research plan is an essential skill for research scientists. This mini course is designed to introduce 2nd year students to the structure and preparation of a structured research proposal as well as formalize instruction in professional standards in research ethics, CV preparation, and scientific writing and data presentation. Course material is taken from actual grant proposals and previous years' qualifying exam proposals, as well as primary research publications and faculty grant proposals. The course is highly interactive, and students are required to participate in review of each others' work throughout the duration of the course. Coursework is expected to form the basis of the Ph.D. qualifying exam proposal in the winter of the second year.

03-750 Graduate Seminar

Fall and Spring: 1 unit

Each semester, all Department of Biological Sciences graduate students are required to register for and attend the weekly departmental Research Seminar (03-750; 1 unit). Graduate students are strongly urged to meet the speakers to broaden their knowledge of cutting-edge biological science, to discuss career paths and strategies and to make useful contacts; the faculty host can arrange group meetings for interested students.

Course Website: http://www.cmu.edu/bio/seminars_events/seminar/index.html**03-751 Advanced Developmental Biology and Human Health**

Fall: 12 units

This course will examine current research in developmental biology, focusing on areas that have important biomedical implications. The course will examine stem cell biology, cellular reprogramming, cell signaling pathways, tissue morphogenesis, and genetic/developmental mechanisms of birth defects and human diseases. Emphasis will be placed on the critical reading of recent, original research papers and classroom discussion, with supporting lectures by faculty.

Prerequisites: 03-330 and 03-240

03-755 Graduate Research Seminar

Fall and Spring: 3 units

Each semester, all Departmental of Biological Sciences graduate students are required to register for and attend the weekly departmental Journal Club (Graduate Research Seminar 03-755; 3 units) during which students and faculty members give 25-minute presentations. Second-year students present a research paper or topic from the literature, and more senior students present their research results; typically, graduate students give four Journal Club presentations during their time in the department. Each succeeding year those students who speak at the Departmental Retreat or who are graduating by May of their fifth year are not required to present at Journal Club that year.

Course Website: http://www.cmu.edu/bio/seminars_events/journal_club/index.html**03-761 Neural Plasticity**

Spring: 9 units

Neural plasticity underlies the capacity of the central nervous system to encode new information, develop new abilities and adapt to the environment. Plasticity is required for learning and is modulated during development and by disorders of the brain. Recent advances in experimental methodology have led to new insights on the biological mechanisms underlying neural plasticity. The topics if the papers chosen for review will center on recent experimental and theoretical studies of topics such as synaptic plasticity, developmental and activity dependent changes in sensory and motor maps.

Prerequisite: 03-360

03-762 Advanced Cellular Neuroscience

Fall: 12 units

This course is an introductory graduate course in cellular neuroscience. As such it will assume little or no background but will rapidly progress to discussions of papers from the primary literature. The structure of the course will be about half lectures and half discussions of new and classic papers from the primary literature. These discussions will be substantially led by students in the course. Topics covered will include ion channels and excitability, synaptic transmission and plasticity, molecular understanding of brain disease and cell biology of neurons. Assessment will be based on class participation, including performance on in-class presentations and a writing assignment.

03-763 Advanced Systems Neuroscience

Spring: 12 units

This course is a graduate version of 03-363. Students will attend the same lectures as the students in 03-363, plus an additional once weekly meeting. In this meeting, topics covered in the lectures will be addressed in greater depth, often through discussions of papers from the primary literature. Students will read and be expected to have an in depth understanding of several classic papers from the literature as well as current papers that illustrate cutting edge approaches to systems neuroscience or important new concepts. Use of animals as research model systems will also be discussed. Performance in this portion of the class will be assessed by supplemental exam questions as well as by additional homework assignments.

Prerequisites: 03-121 or 03-362 or 03-762

03-770 Principles of Biotechnology

Spring: 12 units

This course is intended to provide an introduction to a set of core areas important for understanding and managing biotechnology business. Essentially, the focus of the course will be the basics of the biotechnology entrepreneurial process and a deep background on biotechnology enabled products. The objective is to provide the background for management-level personnel to make decisions based on knowledge of contemporary biotechnologies and the legal and regulatory environment. Because it is impossible to be comprehensive with regard to all applications, the goal is to provide students with sufficient familiarity with current biotechnology and with a framework for assessing bio-related business questions that they may encounter in the future through a combination of independent research, assessment of opportunities and pitfalls, and historical comparisons. NOTE: This course CANNOT count towards the advanced electives required for majors or minors in Biological Sciences.

03-791 Advanced Microbiology

Spring: 12 units

This course will use both lectures and current research literature in the area of Microbiology and Infectious Diseases to introduce such topics as prokaryotic cytoskeletal functions, the human microbiome and its impact, metabolic engineering, transposon mutagenesis for gene function elucidation, synthetic genome construction and applications, pathogenicity islands, functional and expression-based identification of pathogenicity determinants, horizontal gene transfer, regulatory RNAs, biofilm formation quorum sensing, and antimicrobial drug development.

03-871 Structural Biophysics

Fall: 12 units

The physical properties of biological macromolecules and the methods used to analyze their structure and function are discussed. Topics covered include: protein architecture and folding; nucleic acid structures and energetics; structure determination by X-ray crystallography and NMR; biological spectroscopy with emphasis on absorption, fluorescence, and NMR spectroscopies; other methods to characterize proteins and protein-ligand interactions, such as mass spectrometry, calorimetry, and surface plasmon resonance. Sufficient detail is given to allow the student to critically evaluate the current literature.

Prerequisites: (03-231 or 03-232) and (09-214 or 09-345) and (21-120 or 21-122)

03-900 Doctoral Thesis Research

All Semesters

Doctoral Thesis Research consists of an independent investigation on a project selected from a major area of research study with the advice and approval of the faculty advisor.

Biomedical Engineering Courses**42-101 Introduction to Biomedical Engineering**

Fall and Spring: 12 units

This course will provide exposure to basic biology and engineering problems associated with living systems and health care delivery. Examples will be used to illustrate how basic concepts and tools of science & engineering can be brought to bear in understanding, mimicking and utilizing biological processes. The course will focus on four areas: biotechnology, biomechanics, biomaterials and tissue engineering and biosignal and image processing and will introduce the basic life sciences and engineering concepts associated with these topics. Pre-requisite OR co-requisite: 03-121 Modern Biology.

Corequisite: 03-121

42-200 Sophomore BME Research Project

Fall and Spring

Research projects for sophomores under the direction of a regular or adjunct BME faculty member. Arrangements may also be made via the Associate Head of BME for off-campus projects provided that a regular or adjunct BME faculty member agrees to serve as a co-advisor. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the research advisor. The agreement should be summarized in a two-page project description with sign-off by the research advisor and a copy submitted for review and filing with the BME Department. A final written report or oral presentation of the results is required. Units may vary from 9 to 12 according to the expected time commitment, with one unit corresponding to 1 hour of research per week. One (but not more than one) semester of research, if registered for at least 9 units, may be counted as a restricted elective course toward the BME additional major.

42-201 Professional Issues in Biomedical Engineering

Fall and Spring: 3 units

This course exposes students to many of the issues that biomedical engineers face. It provides an overview of professional topics including bioethics, regulatory issues, communication skills, teamwork, and other contemporary issues. Outside speakers and case studies will describe real world problems and professional issues in biotechnology and bioengineering, and progress toward their solution. Prerequisite or co-requisite: 42-101 Introduction to Biomedical Engineering

Prerequisite: 42-101

42-202 Physiology

Fall and Spring: 9 units

This course is an introduction to human physiology and includes units on all major organ systems. Particular emphasis is given to the musculoskeletal, cardiovascular, respiratory, digestive, excretory, and endocrine systems. Modules on molecular physiology tissue engineering and physiological modeling are also included. Due to the close interrelationship between structure and function in biological systems, each functional topic will be introduced through a brief exploration of anatomical structure. Basic physical laws and principles will be explored as they relate to physiologic function. Prerequisite or co-requisite: 03-121 Modern Biology, or permission of instructor.

Corequisite: 03-121

42-203 Biomedical Engineering Laboratory

Fall and Spring: 9 units

This laboratory course is designed to provide students with the ability to make measurements on and interpret data from living systems. The experimental modules reinforce concepts from 42-101 Introduction to Biomedical Engineering and expose students to four areas of biomedical engineering: biomedical signal and image processing, biomaterials, biomechanics, and cellular and molecular biotechnology. Several cross-cutting modules are included as well. The course includes weekly lectures to complement the experimental component. Prerequisites: 42-101 Introduction to Biomedical Engineering and 03-121 Modern Biology. Pre-med students should register for 03-206. Priority for enrollment will be given to students who have declared the Additional Major in Biomedical Engineering. Prerequisites: 42-101 and 03-121

42-300 Junior BME Research Project

Fall and Spring

Research projects for juniors under the direction of a regular or adjunct BME faculty member. Arrangements may also be made via the Associate Head of BME for off-campus projects provided that a regular or adjunct BME faculty member agrees to serve as a co-advisor. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the research advisor. The agreement should be summarized in a two-page project description with sign-off by the research advisor and a copy submitted for review and filing with the BME Department. A final written report or oral presentation of the results is required. Units may vary from 9 to 12 according to the expected time commitment, with one unit corresponding to 1 hour of research per week. One (but not more than one) semester of research, if registered for at least 9 units, may be counted as a restricted elective course toward the BME additional major.

42-341 Introduction to Biomechanics

Fall: 9 units

This course covers the application of solid and fluid mechanics to living tissues. This includes the mechanical properties and behavior of individual cells, the heart, blood vessels, the lungs, bone, muscle and connective tissues as well as methods for the analysis of human motion.

Prerequisites: 12-355 or 24-231 or 06-261

42-400 Senior BME Research Project

Fall and Spring

Research projects for seniors under the direction of a regular or adjunct BME faculty member. Arrangements may also be made via the Associate Head of BME for off-campus projects provided that a regular or adjunct BME faculty member agrees to serve as a co-advisor. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the research advisor. The agreement should be summarized in a two-page project description with sign-off by the research advisor and a copy submitted for review and filing with the BME Department. A final written report or oral presentation of the results is required. Units may vary from 9 to 12 according to the expected time commitment, with one unit corresponding to 1 hour of research per week. One (but not more than one) semester of research, if registered for at least 9 units, may be counted as a restricted elective course toward the BME additional major.

42-401 Foundation of BME Design

Fall: 6 units

This course introduces Biomedical Engineering students to the design of useful biomedical products. Students will learn to identify product needs, how to specify problem definitions and to use project management tools. Methods to develop creativity in design will be introduced. Students will form project teams and select a project to be completed during the following semester in 42-402. This course culminates in the completion of a design brief. Prerequisite: Senior standing in Biomedical Engineering. Co-requisite: 42-101.

Corequisite: 42-101

42-402 BME Design Project

Spring: 9 units

This course focuses on integrated product development for biomedical products. Teams will consist of a variety of Biomedical Engineering students. The course consists of modules including the development of a project plan, background research, hazard analysis, setting product specifications based on user requirements, detailed design and analysis, prototype development and final documentation and presentation. Additional relevant professional development topics are also covered, including technical public speaking, proposal preparation, personal time management, and other topics. All products developed will respond to the needs of appropriate market segments; resulting products will be deemed safe, effective, useful, usable and desirable by those segments. Students will produce a form model, functional prototype, marketing plan, and manufacturing plan of their product. Prerequisite: 42-401 (Fall) Foundations of Biomedical Engineering Design

42-411 Engineering Biomaterials

Fall: 9 units

This course will cover structure-processing-property relationships in biomaterials for use in medicine. This course will focus on a variety of materials including natural biopolymers, synthetic polymers, and soft materials with additional treatment of metals and ceramics. Topics include considerations in molecular design of biomaterials, understanding cellular aspects of tissue-biomaterials interactions, and the application of bulk and surface properties in the design of medical devices. This course will discuss practical applications of these materials in drug delivery, tissue engineering, biosensors, and other biomedical technologies. Cross-listed with 27-411

Prerequisites: 06-221 or 24-221 or 27-215

42-426 Biosensors and BioMEMS

Intermittent: 9 units

This course emphasizes the principles of biomolecule-based sensing, including molecular recognition, biomolecular binding kinetics and equilibrium; methods of detection and signal transduction, including optical, colorimetric, fluorescence, potentiometric, and gravimetric techniques; statistical principles of high throughput screening; microfluidic and microarray device design principles and fabrication technologies; molecular motors. Prerequisites: 03-231 OR 03-232 Biochemistry.

Prerequisite: 03-232

42-431 Introduction to Biomedical Imaging and Image Analysis

Fall: 12 units

This course gives an overview of tools and tasks in various biological and biomedical imaging modalities, such as microscopy, magnetic resonance imaging, x-ray computed tomography, ultrasound and others. Students will be exposed to the major underlying principles in modern imaging systems as well as state of the art methods for processing biomedical images such as deconvolution, registration, segmentation, pattern recognition, etc. The discussion of these topics will draw on approaches from many fields, including physics, statistics, signal processing, and machine learning. As part of the course, students will be expected to complete an independent project. Students will have the opportunity to visit laboratory to see real biomedical imaging devices in action. Prerequisites: 18-290 Signals and Systems or permission of the instructor, working knowledge of Matlab, and some image processing experience. Cross-listed courses: 18-496

Prerequisites: 18-290 and 42-202

42-444 Medical Devices

Fall: 9 units

This course is an introduction to the engineering, clinical, legal and regulatory aspects of medical device performance and failure. Topics covered include a broad survey of the thousands of successful medical devices in clinical use, as well as historical case studies of devices that were withdrawn from the market. In-depth study of specific medical devices will include: cardiovascular medicine, orthopedics, and general medicine. We will study the principles of operation (with hands-on examples), design evolution, and modes of failure. Additional lectures will provide basic information concerning biomaterials used for implantable medical devices (metals, polymers, ceramics) and their biocompatibility, mechanisms of failure (wear, corrosion, fatigue, fretting, etc.). The level of technical content will require junior standing for MCS and CIT students, a degree in science or engineering for non-MCS or non-CIT graduate students, or permission of the instructor for all other students.

42-447 Rehabilitation Engineering

Fall: 9 units

Rehabilitation engineering is the systematic application of engineering sciences to design, develop, adapt, test, evaluate, apply, and distribute technological solutions to problems confronted by individuals with disabilities. This course surveys assistive technologies designed for a variety of functional limitations - including mobility, communication, hearing, vision, and cognition - as they apply to activities associated with employment, independent living, education, and integration into the community. This course considers not only technical issues in device development, but also the psychosocial factors and market forces that influence device acceptance by individuals and the marketplace.

42-612 Tissue Engineering

Spring: 12 units

This course will train students in advanced cellular and tissue engineering methods that apply physical, mechanical and chemical manipulation of materials in order to direct cell and tissue function. Students will learn the techniques and equipment of bench research including cell culture, immunofluorescent imaging, soft lithography, variable stiffness substrates, application/measurement of forces and other methods. Students will integrate classroom lectures and lab skills by applying the scientific method to develop a unique project while working in a team environment, keeping a detailed lab notebook and meeting mandated milestones. Emphasis will be placed on developing the written and oral communication skills required of the professional scientist. The class will culminate with a poster presentation session based on class projects. Pre-requisite: Knowledge in cell biology and biomaterials, or permission of instructor

42-620 Engineering Molecular Cell Biology

Fall: 12 units

Cells are not only basic units of living organisms but also fascinating engineering systems that exhibit amazing functionality, adaptability, and complexity. Applying engineering perspectives and approaches to study molecular mechanisms of cellular processes plays a critical role in the development of contemporary biology. At the same time, understanding the principles that govern biological systems provides critical insights into the development of engineering systems, especially in the micro- and nano-technology. The goal of this course is to provide basic molecular cell biology for engineering students with little or no background in cell biology, with particular emphasis on the application of quantitative and system perspectives to basic cellular processes. Course topics include the fundamentals of molecular biology, the structural and functional organization of the cell, the cytoskeleton and cell motility, the mechanics of cell division, and cell-cell interactions. Pre-requisites: 21-260 Differential Equations, or 06-262 Mathematical Methods of Chemical Engineering, or 18-202 Mathematical Foundations of Electrical Engineering. Advanced undergraduate or graduate student standing is required. Prior completion of 03-121 Modern Biology is suggested but not required. Proficiency in basic computation such as MATLAB programming is expected.

42-622 Bioprocess Design

Spring: 9 units

This course is designed to link concepts of cell culture, bioseparations, formulation and delivery together for the commercial production and use of biologically-based pharmaceuticals; products considered include proteins, nucleic acids, and fermentation-derived fine chemicals. Associated regulatory issues and biotech industry case studies are also included. The format of the course is a mixture of equal parts lecture, open discussion, and participant presentation. Course work consists of team-oriented problem sets of an open-ended nature and individual-oriented industry case studies. The goals of the course work are to build an integrated technical knowledge base of the manufacture of biologically based pharmaceuticals and U.S. biotechnology industry. Working knowledge of cell culture and modern biology, biochemistry and differential equations is assumed. Pre-requisite: 42-321 Cellular and Molecular Biotechnology or both 03-232 Biochemistry and 06-422 Chemical Reaction Engineering, or instructor permission. Prerequisites: 06-422 or 42-321 or 03-232

42-623 Cellular and Molecular Biotechnology

Fall: 9 units

This course will provide students with an introduction to biotechnology in an engineering context. The focus will be on using microorganisms to prepare therapeutically and technologically relevant biochemicals. Topics to be covered include cellular and microbial metabolism, recombinant DNA methodologies, bioreactor design, protein separation and purification, and systems approaches to biotechnology. Prerequisites: (42-202 Physiology OR 03-121 Modern Biology OR 03-232 Biochemistry) AND (06-262 Mathematical Methods of Chemical Engineering OR 21-260 Differential Equations) OR permission of instructor.

42-624 Biological Transport and Drug Delivery

Spring: 9 units

Analysis of transport phenomena in life processes on the molecular, cellular, organ and organism levels and their application to the modeling and design of targeted or sustained release drug delivery technologies. Coupling of mass transfer and reaction processes will be a consistent theme as they are applied to rates of receptor-mediated solute uptake in cells, drug transport and biodistribution, and drug release from delivery vehicles. Design concepts underlying advances in nanomedicine will be described.

42-630 Introduction to Neuroscience for Engineers

Intermittent: 12 units

The first half of the course will introduce engineers to the neurosciences from the cellular level to the structure and function of the central nervous system (CNS) and include a study of basic neurophysiology; the second half of the course will review neuroengineering methods and technologies that enable study of and therapeutic solutions for diseases or damage to the CNS. A goal of this course is provide a taxonomy of neuroengineering technologies for research or clinical application in the neurosciences.

42-631 Neural Data Analysis

Fall: 9 units

The vast majority of behaviorally relevant information is transmitted through the brain by neurons as trains of action potentials. How can we understand the information being transmitted? This class will cover the basic engineering and statistical tools in common use for analyzing neural spike train data, with an emphasis on hands-on application. Topics may include neural spike train statistics (Poisson processes, interspike intervals, Fano factor analysis), estimation (MLE, MAP), signal detection theory (d-prime, ROC analysis, psychometric curve fitting), information theory, discrete classification, continuous decoding (PVA, OLE), and white-noise analysis.

42-632 Neural Signal Processing

Fall: 12 units

The brain is among the most complex systems ever studied. Underlying the brain's ability to process sensory information and drive motor actions is a network of roughly 10^{11} neurons, each making 10^3 connections with other neurons. Modern statistical and machine learning tools are needed to interpret the plethora of neural data being collected, both for (1) furthering our understanding of how the brain works, and (2) designing biomedical devices that interface with the brain. This course will cover a range of statistical methods and their application to neural data analysis. The statistical topics include latent variable models, dynamical systems, point processes, dimensionality reduction, Bayesian inference, and spectral analysis. The neuroscience applications include neural decoding, firing rate estimation, neural system characterization, sensorimotor control, spike sorting, and field potential analysis. Prerequisites: 18-290; 36-217, or equivalent introductory probability theory and random variables course; an introductory linear algebra course; senior or graduate standing. No prior knowledge of neuroscience is needed.

42-640 Computational Bio-Modeling and Visualization

Spring: 12 units

Biomedical modeling and visualization play an important role in mathematical modeling and computer simulation of real/artificial life for improved medical diagnosis and treatment. This course integrates mechanical engineering, biomedical engineering, computer science, and mathematics together. Topics to be studied include medical imaging, image processing, geometric modeling, visualization, computational mechanics, and biomedical applications. The techniques introduced are applied to examples of multi-scale biomodeling and simulations at the molecular, cellular, tissue, and organ level scales.

42-643 Microfluids

Intermittent: 12 units

This course offers an introduction to the emerging field of microfluidics with an emphasis on chemical and life sciences applications. During this course students will examine the fluid dynamical phenomena underlying key components of "lab on a chip" devices. Students will have the opportunity to learn practical aspects of microfluidic device operation through hands-on laboratory experience, computer simulations of microscale flows, and reviews of recent literature in the field. Throughout the course, students will consider ways of optimizing device performance based on knowledge of the fundamental fluid mechanics. Students will explore selected topics in more detail through a semester project. Major course topics include pressure-driven and electrokinetically-driven flows in microchannels, surface effects, micro-fabrication methods, micro/nanoparticles for biotechnology, biochemical reactions and assays, mixing and separation, two-phase flows, and integration and design of microfluidic chips. Pre-requisites: 24-231 or 06-261 or 12-355 or instructor permission.

42-645 Cellular Biomechanics

Intermittent: 9 units

This course discusses how mechanical quantities and processes such as force, motion, and deformation influence cell behavior and function, with a focus on the connection between mechanics and biochemistry. Specific topics include: (1) the role of stresses in the cytoskeleton dynamics as related to cell growth, spreading, motility, and adhesion; (2) the generation of force and motion by motor molecules; (3) stretch-activated ion channels; (4) protein and DNA deformation; (5) mechanochemical coupling in signal transduction. If time permits, we will also cover protein trafficking and secretion and the effects of mechanical forces on gene expression. Emphasis is placed on the biomechanics issues at the cellular and molecular levels; their clinical and engineering implications are elucidated. 3 hrs. lec. Prerequisite: Instructor permission. Prerequisites: None. Corequisites: None. Cross Listed Courses: 24-655 Notes: None. Reservations:

42-646 Molecular Biomechanics

Spring: 9 units

This class is designed to present concepts of molecular biology, cellular biology and biophysics at the molecular level together with applications. Emphasis will be placed both on the biology of the system and on the fundamental physics, chemistry and mechanics which describe the molecular level phenomena within context. In addition to studying the structure, mechanics and energetics of biological systems at the nano-scale, we will also study and conceptually design biomimetic molecules and structures. Fundamentals of DNA, globular and structured proteins, lipids and assemblies thereof will be covered.

42-647 Introduction to Continuum Biomechanics

Spring: 12 units

This course provides a general survey of the application of continuum mechanics (fluid and solid mechanics) to biomechanics. The course as whole encourages class participation and discussion in a seminar-type fashion. The course begins with a historical review of the subject followed by a review of vector and tensor analysis, before discussing various measures of deformation and stress formulations. The development and understanding of appropriate constitutive models for particular problems are at the core of this course. Both analytical and to some extent experimental results are presented through readings from reports in recent journals and the relevance of these results to the solution of unsolved problems is highlighted. The main objective of this course is to provide the basic ideas of continuum mechanics for engineering and science students with little or no background in Biomechanics, with particular emphasis on the application of quantitative and system perspectives to fluid and solid mechanics problems. In addition to looking at various examples with biomechanics applications, the last few weeks of the course are dedicated to discussing individually-crafted research projects for the students. Pre-requisite or Co-requisite: 21-260 Differential Equations, 24-231 Fluid Mechanics, 24-262 Mechanics of Deformable Solids, or permission of instructor. Corequisites: 24-262 and 24-231 and 21-260

42-648 Cardiovascular Mechanics

Spring: 12 units

The primary objective of the course is to learn to model blood flow and mechanical forces in the cardiovascular system. After a brief review of cardiovascular physiology and fluid mechanics, the students will progress from modeling blood flow in a.) small-scale steady flow applications to b.) small-scale pulsatile applications to c.) large-scale or complex pulsatile flow applications. The students will also learn how to calculate mechanical forces on cardiovascular tissue (blood vessels, the heart) and cardiovascular cells (endothelial cells, platelets, red and white blood cells), and the effects of those forces. Lastly, the students will learn various methods for modeling cardiac function. When applicable, students will apply these concepts to the design and function of selected medical devices (heart valves, ventricular assist devices, artificial lungs).

42-698 Special Topics

Fall and Spring: 9 units

42-698A Bioinstrumentation (Spring), 42-698C Introduction to Biomedical Signal Processing (Fall) 42-698D Engineering in Medicine (Fall), 42-698E Surgery for Engineers (Spring), 42-698G Molecular and Micro-scale Polymeric Biomaterials in Medicine (Spring), 42-698H BME Systems Modeling and Analysis (Fall), 42-698I Biofluid Mechanics (Fall), and 42-698P Introduction to Biophotonics (Fall) Please see <http://www.bme.cmu.edu/ugprog/catalog.html> for detailed course descriptions.

42-699 Special Topics

Fall and Spring: 12 units

42-699G Computational Methods in Biomedical Engineering (Spring), 42-699L Inventive Problem Solving in Biomedical Engineering (Fall), 42-699N Applied Nanoscience and Nanotechnology (Fall), and 42-699P Introduction to Biophotonics (Fall) Please see <http://www.bme.cmu.edu/ugprog/catalog.html> for detailed course descriptions.

42-735 Medical Image Analysis

Spring: 12 units

Students will gain theoretical and practical skills in medical image analysis, including skills relevant to general image analysis. The fundamentals of computational medical image analysis will be explored, leading to current research in applying geometry and statistics to segmentation, registration, visualization, and image understanding. Student will develop practical experience through projects using the National Library of Medicine Insight Toolkit (ITK), a popular open-source software library developed by a consortium of institutions including Carnegie Mellon University and the University of Pittsburgh. In addition to image analysis, the course will include interaction with clinicians at UPMC. It is possible that a few class lectures may be videoed for public distribution. Prerequisites: Knowledge of vector calculus, basic probability, and either C++ or python. Required textbook, "Machine Vision", ISBN: 052116981X; Optional textbook, "Insight to Images", ISBN: 9781568812175. Prerequisite: 03-121

Business Administration Courses**70-100 Global Business**

Fall: 9 units

This course examines the fundamental issues in the development of new markets for products and services globally. It provides a foundation for understanding the functional areas of business and how they contribute to management of a firm. Students use this foundation knowledge to analyze cases and complete projects in order to gain an understanding of some of the key issues affecting a wide range of the most important global industries. First-year students also can gain a better understanding of the vast array of career possibilities available to those who study business. This course is restricted to first-year business majors. Students may not receive credit for both 70-100 and 70-101.

70-101 Introduction to Business Management

Fall and Spring: 9 units

This course examines the fundamental issues in the development of new markets for products and services globally. It provides a foundation for understanding the functional areas of business and how they contribute to management of a firm. Students use this foundation knowledge to analyze cases and complete projects in order to gain an understanding of some of the key issues affecting a wide range of the most important global industries. First-year students also can gain a better understanding of the vast array of career possibilities available to those who study business. Students may not receive credit for both 70-100 and 70-101.

70-110 Business Computing

Fall and Spring: 9 units

Description forthcoming.

70-122 Introduction to Accounting

Fall and Spring: 9 units

This course provides the knowledge and skills necessary for the student to understand financial statements and financial records and to make use of the information for management and investment decisions. Topics include: an overview of financial statements and business decisions; the balance sheet, the income statement, and the cash flow statement; sales revenue, receivables, and cash; cost of goods sold and inventory; long-lived assets and depreciation, and amortization; current and long-term liabilities; owners' equity; investments in other corporations; an introduction to financial statement analysis and international issues dealing with financial statements.

70-160 Graphic Media Management

Fall and Spring: 9 units

This course covers fundamental topics related to graphic media. Modern graphic techniques are studied in context of the historical developments that underlie them. The greatest emphasis is placed on the current graphic processes, but studying their historical development gives the learner better understanding of their applications today, as well as a sense of the direction in which technology can be expected to move in the future. Information from this course can provide professionals in all industries with tactical advantages in choosing among graphic media options when allocating their media budgets. This course is designed to equip students with a measure of graphic literacy, which refers to the skills and knowledge needed to produce graphic documents that enhance the communication aims of the author. Graphic literacy is an invaluable skill for success in the communication age wherein most professionals are engaged in some aspect of producing graphic documents. Topics of investigation include: traditional printing methods, typography, color reproduction, digital photography, digital cinema, papermaking, electronic paper, graphic displays, inks & coatings, finishing techniques, document security, electrophotographic printing, inkjet printing, large format printing, and holography. Open to undergraduates of all class years. No prerequisites.

70-162 Interactive Media Management

Spring: 9 units

Interactive media offers a powerful communication method by providing an immersive, self-guided multi-media environment. This course provides an introduction to project management methods for interactive media, and an introduction to the methods used to create effective interactive media. Classroom instruction is supported by laboratory exercises. Students learn how to conceptualize, manage, and execute an interactive media project that combines text, illustrations, photographs, animations, sound, and video. Open to undergraduates of all class years. Formerly course 70-637, Interactive Media Design Management.

70-196 Publishing on the World Wide Web

Fall and Spring: 9 units

This is an introductory course in Publishing on the World Wide Web. The class has both a classroom component and a lab component. Over the past two decades, the World Wide Web has become an essential communications venue for private individuals and businesses alike. The classroom component of this course examines a variety of topics related to web publishing including: the design and usability of web sites, the appropriate use of file formats, the emergence of e-commerce, the integration of other media, the increased use of mobile devices, the sudden rise of social media, the increased use of 3D environments on the web, the delivery of streaming media across the web, and other topics. The lab component of the class takes the students through a series of exercises beginning with HTML and CSS and progressing to the use of Adobe Dreamweaver, one of the premiere web development software programs. Students use these tools to make well-designed functional websites exhibiting the principles learned in the classroom component of the class. The students are instructed in some of the latest web publishing methods, such as the use of HTML5, CSS3, and fluid grid design which allows the same HTML file to be automatically reconfigured for mobile devices, tablets, and desktop computers. Scripting languages and the development of databases for websites are beyond the scope of this class. Open to undergraduates of all class years. No prerequisites. Formerly course number 70-643.

70-201 Professional and Service Projects

Fall and Spring: 9 units

Professional service is important in career development because it creates opportunities to use skills and knowledge, develop leadership abilities, develop professional networks, and to learn the importance of community involvement and social values in business practice. Students complete a variety of activities with these objectives over a period of up to four semesters to satisfy this course requirement.

70-207 Probability and Statistics for Business Applications

Spring and Summer: 9 units

Elementary ideas in probability, statistics, and data analysis are presented in the context of their importance to modern business management.

Prerequisites: 21-112 or 21-120

70-208 Regression Analysis

Fall and Summer: 9 units

This class focuses on the statistical analysis of the relationship between two or more random variables. In particular, we examine the estimation of the conditional mean of the dependent variable as a function of independent variables using linear regression. We draw on statistical theory to determine the precision of our estimates and to conduct inference about the population, and we examine a number of applications to business, finance, and economics throughout the course.

Prerequisites: (21-112 or 21-120) and (36-201 or 36-220 or 70-207 or 36-247 or 36-207) and 73-100

70-311 Organizational Behavior

Fall and Spring: 9 units

This course examines the factors which influence individual, group and firm behavior in the context of the workplace. Topics covered include perception, group behavior, decision making, motivation, leadership and organizational design and change.

Prerequisites: 76-100 or 76-101 or 76-327 or 76-331 or 76-347 or 76-245

70-321 Negotiation and Conflict Resolution

Fall and Spring: 9 units

This course will complement the technical and diagnostic skills you have learned in other courses. A basic premise of the course is that, while you will need analytical skills to discover optimal solutions to problems, you will also need a broad array of negotiation skills to implement these solutions and make sure that they are truly effective. Your long-term effectiveness - both in your professional and personal life - is likely to depend on your negotiating abilities. This course will give you the opportunity to develop these skills experientially and to understand the analytical frameworks that underlie negotiations.

Prerequisite: 76-101

70-332 Business, Society and Ethics

Fall and Spring: 9 units

The course draws upon actual cases to explore fundamental questions faced by businesses operating in the United States and elsewhere in the world.

What justifies governmental regulation of your business? What are the rights of employers and employees? How does the law protect consumers? What laws protect the environment? How do you choose the best legal form for your business? What are the lines of power within a corporation? What protections are available to shareholders? How do the antitrust laws protect competition? What responsibilities does a business have to the community in which it operates? What is the ethical foundation on which business ought to be conducted? The course puts businesses in their legal and ethical context.

Prerequisite: 76-101

70-339 Information Technology for Finance

Spring: 9 units

The financial services industry is a leader in the use of information technology. Firms in banking, securities, investments, insurance and financial marketplaces are among the most information intensive and innovative users of technology. The course will examine the role and potential of technology in this industry. The course begins with a description of the financial markets, specifically equity, foreign exchange, and derivatives, and the systems that enable them. It considers exchanges, ECNs, ATS's Order Management Systems, Straight through Processing, Fix Protocol, and post trading clearance and settlement. It covers the design, evaluation and execution of popular trading strategies that are used by professionals in the various markets. There is increasing interest, in particular, on systematic trading strategies and execution systems because of their scalability and transparency. The course covers both Algorithmic and High Frequency Trading and analyzes issues regarding latency, scalability, and reliability.

Prerequisite: 70-391

70-340 Business Communications

Fall and Spring: 9 units

Business Communications develops and sharpens your written, oral, and interpersonal communication, introducing you to common forms of professional writing and speaking in specific business situations. The course explores crucial rhetorical issues that impact your ability to communicate and achieve your objectives as a business leader.

Prerequisite: 76-101

70-341 Organizational Communication

Intermittent: 9 units

Much of the work in groups and organizations consists of communication. You communicate to get information that will be the basis of decisions, to provide a vision for the people who work for and with you, to coordinate activity, and to sell yourself and your work. The goal of this course is to identify sources of communication problems within an organization and ways to overcome them. To do this requires that we know how communication normally works, what parts are difficult, and how to fix it when it goes wrong. The focus of this course is on providing you with a broad understanding of the way communication operates within dyads, work groups, and organizations. This course is not a practicum in public speaking or writing, although you will get some experience writing, speaking and managing impressions. Rather the intent is to give you theoretical and empirical underpinnings for the communication you will undoubtedly do when you return to work. Readings come from both the research and the managerial literatures. Among the topics considered are managerial communication, persuasion and conformity, self presentation and person perception, social networks. Cases and group projects give you an opportunity to apply what you've learned.

Prerequisites: 70-207 or 36-247 or 36-225 or 36-220 or 36-217 or 36-207 or 36-201

70-342 Managing Across Cultures

Spring: 9 units

This course is designed for students who expect to do business in other countries or work with people from other cultures. It provides an intellectual framework for understanding other cultures (and eventually one's own), as well as detailed studies of particular countries. It discusses how culture defines organizations, contracts, personal relationships, attitudes toward authority, time and space, ethics, wealth, and subcultures, and how these affect business. Student teams study a culture of their choice and make presentations, based on interviews and literature research.

Prerequisite: 76-101

70-343 Interpersonal Communication

Spring: 9 units

This course examines various types of interpersonal communication usually found in business situations. Topics covered will vary each semester, but can include business and social etiquette, ethics in business, dressing for success, interviewing skills, leadership skills, listening skills, how to run a successful meeting, intercultural communications, motivating employees, negotiating, networking in business, non-verbal communications, performance appraisals, power communication, telephone skills and team/small group communication. Co-curricular events will be required and may include conducting mock interviews, role playing business luncheons and navigating business social events.

Prerequisites: 70-340 or 76-270

70-345 Business Presentations

Fall and Spring: 9 units

In this course, students prepare, present, discuss, and critique the different oral presentations currently practiced in business. Topics include developing verbal and physical presence; planning presentations based on audience needs and expectations; projecting personal credibility, professionalism, and appropriate emotional responses; and using various multi-media technology. Assignments and cases will cover informative and persuasive presentations, which will vary from term to term and may include talks such as formal public introductions; explanations of policy and/or procedures; employee training sessions; state-of-the-company addresses; sales presentations; team-driven strategic plans; public interviews with a hostile press; and talks on other more free-ranging topics.

Prerequisites: 73-270 or 70-340

70-347 Publishing Management in the Information Age

Fall and Spring: 9 units

In this course, the publishing industry is studied from a variety of perspectives, but, primarily, with reference to the changes that have been caused by the phenomenon referred to as the information age. The information age is characterized by the ability of individuals to transfer information freely and have instant access to knowledge that would have been difficult or impossible to find previously. The digitization of information and the rise of electronic media have confounded the traditional publishing houses who have struggled to find their footing in this new environment. The information age has also provided new forms of information dissemination and inexpensive means of self-publishing and on-demand publishing. This course examines the history of the publishing industry in western society including books, magazines, and newspapers. It then looks at the disruptive effect that the information age has had in this industry and at the new publishing paradigms that are evolving to take advantage of digital media. The course also includes lab experiences using Adobe InDesign to help students develop skills in designing and preparing pieces for publication by a variety of media. The lab experiences culminate in an independently published book that is written, designed, and assembled entirely by the students in this course. The book stands as a showcase for the research and journalistic skills of the students, as well as, a clear demonstration of the students' proficiency in the content and skills taught in this course. Although this course is open to undergraduates of all class years, it is aimed at 3rd and 4th year students. No prerequisites. The course has been previously listed as number 70-194.

70-349 Color Reproduction & Management

Fall and Spring: 9 units

Today, we are bombarded by color media in many forms. In the competitive advertising world, the accurate reproduction of color in various media is both a challenge and a necessity. This course examines topics related to the use of color and its reproduction in a variety of media, including photography, print, television, cinema, the Internet. The course is divided into a classroom component and a lab component. Of prime importance are issues related to the successful specification, transfer, measurement, and application of color to maximize communication efficiency. The physical nature of light and properties of color will be reviewed, as will the perceptual and psychological aspects of color. The separation of color and the control parameters for optimum color realism will be examined. Color will be considered in the context of many media including print, video, cinema, and the internet. Modern methods for managing color files to achieve consistent color appearance through different media will be an important focus of the course. This course examines the issues related to color reproduction and the methods by which consistent color appearance can be maintained across a variety of traditional and electronic media. Topics include: the physical nature of light and color, the perception and measurement of color; the capture, separation, and manipulation of color images. The course contains a laboratory component consisting of a series of in-depth exercises in Adobe PhotoShop giving students an opportunity to apply color correction and image manipulation techniques, and to become more adept at using this important software tool. Although this course is open to undergraduates of all class years, it is aimed at 3rd and 4th year students. No prerequisites. The course has been previously listed as number 70-164 and 70-641.

70-350 Acting for Business

Fall and Spring: 9 units

Acting for Business (formerly entitled "Business Acting") is an opportunity to unlock your potential as a communicator through becoming proficient, thorough and masterful at the principles and through a practical interpretation of the techniques of Acting. The course concerns itself with: a new self-awareness and greater confidence in public communication; the expansion and diversification of one's range of personal expression; methods to more effectively shape a public performance and of empowering the student to put his/her best self forward when in contact with an audience; and a re-investment in passion. The course focuses on the goals of: 1) solving issues regarding personal confidence; 2) commanding the space; 3) expanding one's personal comfort zone; 4) achieving the "Audience-Pleasing Form;" 5) utilizing the V.A.T. Communication Tools and 6) beginning to learn the stages in the "Seven Stages to Executive Presence." The participants identify their individual challenges and confront those challenges head-on through the various assignments.

70-352 Business Acting

Spring: 3 units

This is a one-week course that is offered only at CMU in Qatar. This course provides a uniquely broadening educational experience for business students through an exploration & understanding of the process of Acting & the unique performer/audience relationship. Using techniques of Acting, the course will concern itself with: a new self-awareness & greater confidence in public communication; the expansion & diversification of one's range of personal expression; methods to more effectively shape a public performance & of empowering the student to put his/her best Self forward when in contact with an audience; & a re-investment in passion.

70-364 Business Law

Fall and Spring: 9 units

The external political, social and legal environment of the firm and its managers. Legal and regulatory matters, United States and multinational, will be considered, including restrictive trade practices laws and regulations, acquisitions and mergers, licensing, franchising, officers' and directors' responsibilities and liabilities, manufacturers' responsibilities and liabilities, securities regulation, environmental protection, intellectual property, labor unions, trade associations, employee rights and duties, the attorney-client relationship; values in a business society; social implications of business policies, and corporate social responsibility. The effects of laws upon day-to-day business administration. Contracts, sales, commercial paper, the Uniform Commercial Code, credit transactions, bankruptcy, insurance, agency, partnership, incorporation and corporate governance.

Prerequisite: 76-101

70-365 International Trade and International Law

Fall and Spring: 9 units

The course discusses the international legal system and laws that affect international trade. It covers the Foreign Corrupt Practices Act, treaties and concessions, shipping and customs, appointment of foreign sales agents, resolution of trade disputes, international mergers and joint ventures, international competition law, UN sales convention, international trade organizations (IMF, WTO, World Bank, etc.), risk insurance, cultural factors, international E-Commerce and intellectual property.

Prerequisite: 73-100

70-366 Intellectual Property and E-Commerce

Spring: 6 units

The course is intended to instruct students on the creation of the Internet and the World Wide Web, including the creation of the Domain Naming System. The course will provide an understanding of how the WWW "Web" operates (from its creation to the present), how the laws of various countries interact with the Web; how issues of privacy are addressed and the role of private parties and government in monitoring privacy. The course will examine how intellectual property is created and protected; who owns the property; and the role of ownership of the intellectual property interacts with antitrust laws. The course examines how contracts are formed and administered on the Web by entities created to minimize taxes and personal liability risks for the owners/shareholders of those entities.

Prerequisite: 76-101

70-371 Operations Management

Fall and Spring: 9 units

This course is an introduction to production and operations management that covers both manufacturing and services. It deals with strategic issues (design of flexible supply), planning issues (capacity management), and operational issues (inventory management and information). The linkage between strategy and tactics will be emphasized. The students will learn concepts and tools that will help them to manage from the "boardroom" to the "toolroom."

Prerequisites: (21-292 or 21-257) and (36-201 or 36-220 or 36-247 or 36-207 or 70-207)

70-374 Data Mining & Business Analytics

Intermittent: 9 units

Students will use state-of-the-art software on large data sets to illustrate key techniques for finding patterns in data and using them to make better, more effective business decisions.

Prerequisites: 70-208 or 36-202 or 36-208

70-376 Energy Systems

Fall: 9 units

This course will provide students with an understanding of the systems and markets that provide energy to businesses and consumers. Students will be introduced to the sources and uses of energy, and how they have evolved and the possible paths over which they may evolve in the next decades. The course places an emphasis on electric energy, the single largest energy source in many industrial economies, but also covers natural gas, oil, and selected other primary energy sources. Students will learn the energy flows in the USA and the world, as well as the business-relevant characteristics of the engineered systems that provide the energy in various forms. Both traditional and emerging energy sources will be discussed, and students will understand the difference between an energy carrier and an energy source. We will also discuss some of the issues that arise without proper management of the physical risks of energy systems. Students will learn some of the history of electric power regulation and the inconsistent subsidy structures that have provided opportunities and challenges for energy companies and investors, including discussion of how emissions restrictions affect fuel, engineering, investment, and project finance choices. The history of electric power markets will be discussed, with an eye to examining the opportunities that market changes create for business.

70-381 Marketing I

Fall and Spring: 9 units

An introduction to the nature and fundamentals of marketing and consumer behavior. Topics include an analysis of the economic and psychological factors influencing buyer behavior, marketing research, market segmentation, and the development of marketing programs (new product, price, advertising and distribution decisions).

Prerequisite: 76-101

70-385 Consumer Behavior

Spring: 9 units

Marketing, in particular, begins and ends with the consumer from determining consumer needs to ensuring customer satisfaction. In this course, we will explore the most recent scientific research in marketing, psychology, and behavioral economics on judgment and decision-making. We will develop your ability to understand and influence what people want, how people decide what and when to buy, and whether people will be satisfied or dissatisfied with their decisions. These psychological insights are particularly useful for marketing strategy, brand positioning, and marketing communication decisions, but also yield insight into common biases in judgment and decision making, beyond marketing, to which you would otherwise fall prey. Why people are willing to drive across town to save \$5 on a tank of gasoline, for example, when they would not drive a minute to save \$5 on a refrigerator. We will discuss some of these applications in class. In addition, we will examine the methodology of market research (specific to consumer behavior) to build the tools you will need to interpret and base decisions on it.

Prerequisite: 70-381

70-391 Finance

Fall and Spring: 9 units

Firms create value by making good investment decisions. Finance is the field of management science tasked with making this happen. It is a set of tools with which firms identify good investments and decide how to pay for them. Paying for them ultimately involves getting money from households. Therefore, finance also describes the investment decisions of households and the resulting allocation of the economy's resources across firms and time. This course is the introductory finance course in the undergraduate business program. The main topics covered in the course are Financial Markets, Net Present Value, The Objective of the Firm, Discounted Cash Flow, Portfolio Theory and the Cost of Capital, The Efficient Markets Hypothesis, The Capital Structure of the Firm, and Business Valuation. Time permitting, the course will also provide an introduction to option markets and derivative securities. Upon completing the course a student will be able to consider a large and complex business problem, make some assumptions, structure the firms' cash flows in a spreadsheet, calculate the value of different solutions to the problem, and make a decision.

Prerequisites: 73-100 and (36-207 or 36-217 or 36-225 or 70-207 or 36-201)

Course Website: http://bertha.tepper.cmu.edu/telmerc/70391/syllabus_70391.html

70-395 Funding Entrepreneurial Ventures

Fall: 9 units

So you want to do a startup and you know that you need funding. There are multiple ways to fund a new venture: bootstrapping, economic development, angels, venture capitalists. The question is what are these funders looking for in an early stage investment? What is important to them? How do they decide which companies to invest in and which not? This class looks at funding from the funder's point of view and provides the student with a framework of the investment process: investment criteria, sourcing, selection, due diligence, deal structure, valuation, post investment involvement. Real companies seeking funding are used for the final project in which students will be expected, as investment teams, to make investment decisions and convince their fellow investors (the class) to join them (or not). This is a highly interactive and project class. There will be multiple guest speakers. Prerequisites: Students are highly encouraged to take any of the introductory entrepreneurship classes offered in various schools and departments. While no financial background is required, this class will not cover the basics of entrepreneurship from the entrepreneur's perspective, but will be looking from the investor point of view.

70-397 Introduction to Entrepreneurial Finance

Spring: 6 units

This course covers the financing of high-growth entrepreneurial firms with a focus on venture capital. We will discuss the issues entrepreneurial firms in high-growth, innovative industries face when funding their investments and how venture capital and angel investing can mitigate them. Issues will include business plan evaluation, the economics of venture capital funds and the sources of value in entrepreneurial firms. Major topics include a detailed look at the financial market (angels, venture capital and private equity), an analysis of assets and liabilities in an entrepreneurial firm, structuring the ownership of start-ups, and the multiple valuation methods available for investment assessment. Rather than preparing students to become venture capitalists or angel investors, the course provides material to help potential entrepreneurs navigate the financing environment.

70-398 International Finance

Spring: 9 units

International Finance is an elective course designed to give students the opportunity to analyze real-world problems in international capital markets. Topics covered include: exchange rate determination and quoting, international parity relations, foreign exchange hedging strategies using forwards and options, foreign exchange exposure management, international bond market, currency swap market, global equity market, international portfolio risk assessment and performance measurement. Students develop problem solving and communication skills with presentations and critical discussions of case studies. Prerequisite: 70-391

70-401 Management Game

Fall and Spring: 12 units

This course is designed to integrate the managerial concepts and techniques studied earlier in the curriculum and to focus on elements of organizational structure and behavior. Student teams assume the role of top management of firms competing in an international economy simulated by the Carnegie Mellon University Management Game. Each team is responsible to a Board of Directors comprised of alumni of the MBA program and business masters students. Emphasis is placed on the development and implementation of sound organizational decision structures as well as the formulation of effective competitive strategies.

Prerequisites: 70-381 and 70-391 and 70-371 and 70-122

70-414 Entrepreneurship for Engineers

Fall: 9 units

This introductory course in entrepreneurship primarily targets non-business students and assumes no background in business. Students majoring in science, computer science, engineering, the humanities or the arts are exposed to fundamental concepts and issues around innovation and entrepreneurship. The course provides a foundation for starting a new venture and innovating new technologies and products within existing organizations. Topics covered will include: identifying a business opportunity, building a team, finance, equity investment, managing risk, market understanding, and competitive advantage. Emphasis will be on team projects, including developing an investor pitch for an original idea.

70-415 Introduction to Entrepreneurship

Fall and Spring: 9 units

This course is designed primarily to provide an overview of entrepreneurship, develop an entrepreneurial frame of mind and learn the rudiments of how to differentiate an idea from an opportunity. Students come up with a business idea and explore its potential for becoming a viable business. They learn to do market research and experience first-hand the rewards and difficulties in dealing with people in the real world. They will meet entrepreneurs and business professionals as part of the course and learn how to make effective presentations - both written and oral. Other important aspects of the course include self-assessment to determine one's strengths and weaknesses, understanding the "magic" of leadership and gaining an entrepreneurial perspective on life.

70-416 New Venture Creation

Spring: 9 units

This course exposes students to the nuances of financing new ventures, getting them started legally and marketing their products or services. Students pull together all the ideas and information from different functional aspects of their projects into coherent and persuasive mini-business plans that serve as roadmaps for building their businesses; and useful instruments to find sufficient financing for the new ventures, so that they can convince the outside world that these opportunities are viable, with substantial potential for success.

Prerequisites: 70-420 or 70-415 or 70-414 or 15-390 or 70-421

70-420 Entrepreneurship for Scientists

Fall: 9 units

Entrepreneurship for Scientists is an introductory course in entrepreneurship. The course primarily targets non-business students and assumes no background in business. Students majoring in science, computer science, engineering, the humanities or the arts are exposed to fundamental concepts and issues around innovation and entrepreneurship. The course provides a foundation for starting a new venture and innovating new technologies and products within existing organizations. Topics covered will include: identifying a business opportunity, building a team, finance, equity investment, managing risk, market understanding, and competitive advantage. Emphasis will be on team projects, including developing an investor pitch for an original idea.

70-421 Entrepreneurship for Computer Scientists

Fall: 9 units

This course is primarily for non-business school students; it includes most of Introduction to Entrepreneurship (70-415), assumes no background courses in business and involves additional sessions for core business concepts. Students with majors in science, technology, engineering or computer science are exposed to fundamental concepts and issues in innovation, business and entrepreneurship. Students can expect to gain a basic understanding of functional areas such as finance, funding, marketing, sales and management. Student Status: Sophomore year or higher.

70-422 Managerial Accounting

Intermittent: 9 units

The purpose of this course is to provide an introduction to the measurement and allocation of costs. Emphasis will be given to the use of cost information in decision making in organizations. The course will cover standard topics in cost accounting, such as cost behavior and relevant costs, and will connect these to broader issues in microeconomics, decision theory, corporate finance, and operations management. Classes will be a mixture of conventional lectures and laboratory experiments.

Prerequisites: 70-122 and (36-201 or 36-207 or 70-207)

70-423 Technology-Based Entrepreneurship

Spring: 9 units

This course is offered only at Carnegie Mellon's campus in Qatar. This course is designed as an introduction to entrepreneurship and basic business concepts for engineering and science students. There are no prerequisites. Students learn basic business concepts, business models, entrepreneurial thinking, idea generation, opportunity recognition, and the basics of accounting, marketing and strategy development. There is no final examination. Instead, students, working in teams, generate an original idea for a startup business and prepare a business plan and an investor presentation, which sets forth the basic strategies, business models and evaluates the opportunity afforded by their original idea. This course also is consistent with the broad mission of Carnegie Mellon University in Qatar's entrepreneurship program, which is described below. The broad mission of the entrepreneurship program at Carnegie Mellon University in Qatar is three-pronged: a. To encourage and develop entrepreneurial and innovative thinking in a business setting, whether or not it is a startup company; b. To obtain the basic skills to start a new venture; c. To stimulate self-evaluation for life direction.

70-424 Corporate Financial Reporting

Fall and Spring: 9 units

This course is designed to strengthen your ability to correctly interpret financial statements and their accompanying disclosures. The course is aimed at anyone whose career might involve working with accounting data, and should be especially useful for those interested in consulting and financial analysis. Throughout the semester we will discuss the key disclosure rules in the United States, the communication methods available to managers, managers' incentives and ability to exert discretion over reported earnings, and the interplay between a company's corporate strategy and its financial reporting policies and practices. The course emphasizes a number of topics of recent interest to the business community including the quality of earnings, mergers and acquisitions, purchased R&D, post employment benefits, executive compensation, and intangible assets. Prerequisite: 70-122

70-425 Entrepreneurship for the Creative Industries

Spring: 9 units

This is an introductory course designed primarily for undergraduates in the College of Fine Arts who want to create new businesses, products, services, or thriving careers as independent artists. Students can expect to develop an entrepreneurial mindset, learn how creative firms and industries are structured, and build practical skills for finding, evaluating and putting entrepreneurial opportunities into action. We will analyze real world examples, for-profit and not-for-profit, from film, art, architecture, fashion, music, media, theater, retail, and design. The class will explore the core functional areas critical to building entrepreneurial entities, including teams, ideation, marketing and sales, financial analysis, and funding. Interdisciplinary teams will generate ideas and explore their potential as viable businesses or sustainable not-for-profits. Lectures, guest speakers, case studies, and exercises will also be integrated.

70-428 Financial Statement Analysis

Fall and Spring: 9 units

This course is about fundamental analysis using financial statements. We develop and apply technologies for understanding and identifying firm activities that generate shareholder value and for developing valuation benchmarks. The ultimate goal of such analysis is to aid the security valuation and risk analysis exercises. This course is intended to help students establish a good foundation and introduce students the basics of equity and debt analysis techniques. Taking Finance (70-391) before this course is recommended, though not a formal prerequisite. Prerequisite: 70-122

70-430 International Management

Spring: 9 units

This course uses the case method to examine the strategic and operational issues in management practice and decision-making that are important in operating a business that spans national borders. Topics include political and economic risk assessment, technology transfer, cultural analysis, negotiation, social responsibility, organization structure, supply chain management and trends in foreign direct investment and their impact on developing strategies for entering and becoming successful in international markets.

70-437 Organizational Learning and Strategic Management

Fall: 9 units

Managing knowledge effectively is key to the performance and competitiveness of both entrepreneurial and established organizations. The course examines why some organizations are better than others at learning from experience and developing new knowledge. The course focuses on how organizations innovate or create new knowledge, how they retain knowledge, and how they transfer knowledge throughout enterprises. Strategic implications of new results on organizational learning and knowledge management are also developed. Students will acquire a greater appreciation of the dynamics of organizations and factors contributing to their successful performance. A mix of lectures, cases and exercises are used to increase your ability to create, retain and transfer knowledge effectively in organizations. Prerequisites: 36-220 or 36-225 or 36-226 or 36-217 or 36-202 or 36-208 or 70-208

70-438 Commercialization and Innovation

Spring: 9 units

This course targets innovators and entrepreneurs who are interested in introducing innovations to the marketplace through start-up, emerging and established organizations. Class participants will learn how to evaluate, develop and implement opportunities for innovation, using an emergent or iterative approach (the lean methodology). Selected industries of interest of importance for economic growth are analyzed. Opportunities for driving or anticipating change are examined using prevailing SET factors (societal, economic, technology). Students then learn a methodology to identify Signals of change involving three customer groups and one non-customer group - undershot customers, non-consumers, overshot customers, in addition to the nonmarket contexts. The Competitive set is analyzed and strategic choices are made. The Resources, Processes and Values (RPV) of the competitive set are analyzed and utilized for informed decision making. Prerequisites: 73-100 and (70-421 or 70-414 or 70-415 or 70-420)

70-440 Corporate Strategy

Spring: 9 units

This course is designed to provide the student with a general management perspective and an understanding of the total business enterprise. It builds upon previous course work in functional areas and provides insights and analytical tools which a general manager should have in order to plan and implement successful business strategy. The student will analyze complex business problems and formulate realistic strategic solutions. Emphasis is placed on the practical application of business theory by the student in his/her business career. Prerequisite: 70-122

70-442 Principles of Game Theory for Business

Intermittent: 6 units

Game theory is the formal study of strategic interaction and aims to help us understand situations where rational decision makers interact. This course will focus on the theory of non-cooperative games with an emphasis on economic and business applications. In particular, we will use equilibrium analysis to study topics including competition, credible threats, commitment problems, and the strategic use of information via signaling and screening. Prerequisites: (36-207 or 70-207) and (80-305 or 73-230)

70-443 Digital Marketing and Social Media Strategy

Spring: 9 units

This course explores issues related to digital and social media marketing. This is a hands-on class where you will use real world data, case studies and participation in Google online marketing challenge. The following topics would be covered in detail: (a) Search Engine Optimization - you will learn how search engines, keyword auctions, and search engine marketing work, and how to optimize your pay per click advertisement efforts; (b) Econo-Mining - you will also learn on how firms are getting or can get useful information from user generated content using text mining and opinion mining capabilities to drive their product development, placement and advertisement decisions. Using real world data you will analyze whether the traditional approaches for driving advertising or product development strategy are in alignment with what you learn from user generated content; (c) Social Media Marketing - you will learn how to design a social media marketing campaign. What are the key ingredients that make such campaigns successful? How do you run a campaign for a viral product; (d) Forecasting Demand Using Publicly Available Online Search Data - you will learn how to build better forecasting models for demand using Google search data (Google Trends and Insights); (e) Wisdom of the Crowds: we will cover how to design crowdsourcing contests, what and how to crowdsource. You will also learn what prediction markets are, how they work, how to design them, when prediction markets are successful and what kinds of questions are best suited for prediction markets.

70-449 Social, Economic and Information Networks

Spring: 9 units

Interaction is a fundamental part of social science: firms market products to consumers, people share opinions and information with their friends, workers collaborate on projects, agents form alliances and coalitions. In this course, we will use the emerging field of social networks to put structure on this diverse mass of connections. Using a mixture of theoretical, empirical, and computational methods, we will learn about the structure and function of social networks. We will look at how an individual's position in a social network reflects her role in the community. We will learn to identify tastemakers and trendsetters by looking at how information moves through our increasingly connected society. We will consider how our own position in the social network affects our behavior, opinions, and outcomes. And we will explore where social networks come from, and what affects their structure. The material in this course will be interdisciplinary, drawn from the fields of math, computer science, physics, sociology, political science, and economics. By the end of the course, you will have the tools and knowledge needed to analyze social networks on your own. The course is capped with a project where you will use your skills to answer your own questions.

Prerequisites: 73-230 and (36-207 or 70-207 or 36-201)

70-451 Management Information Systems

Fall and Spring: 9 units

The objectives of this course are to provide students with basic knowledge of the technology used in computer-based information systems and to enable them to acquire the skills for analyzing how to manage this technology in business. There is a strong emphasis on how to become both an intelligent user of information systems and also an effective participant in the design process of these systems. Credit will not be permitted for both this course and the Information Systems major course 67-272.

Prerequisites: 15-110 or 15-112

70-453 Business Technology for Consulting

Spring: 9 units

This course is designed to provide students with a basic understanding of how to develop and implement computer-based management information systems. Students will be introduced to a variety of system development concepts and techniques. These can include traditional approaches such as top-down or structured analysis, problem definition, feasibility analysis, enterprise analysis and data flow diagrams, as well as interactive and iterative development approaches such as prototyping and object-oriented concepts and techniques. The course also explores topics related to successful implementation of systems such as testing strategies, project management, user-oriented design and software maintenance. Students will work in teams to analyze, design and build a small information system.

Prerequisite: 70-451

70-455 Modern Data Management

Spring: 9 units

The objective of this course is to learn how to manage data for making critical business decisions. "Data Management" in this course includes both the analysis of various sizes and types of data and their synthesis into fact-based, data-driven recommendations. The course teaches the use of advanced functions in Excel, the abstraction and representation of business situations as entity relationship diagrams, the transformation of such diagrams into database schemata, and the use of Structured Query Language to manipulate cloud-based databases. By the end of this course students should be able to analyze data of varying sizes with varying tools and synthesize clear business recommendations. Our goal is to impart fundamental analytical skills that allow our students to exploit the data rich business environment of today. There will be a large number of in-class, hands-on exercises throughout the course to familiarize you with these topics. Be prepared to bring your laptops. No specific computer skills are required.

70-460 Mathematical Models for Consulting

Fall: 9 units

This course covers a wide variety of mathematical models and techniques used by consultants and which lie at the heart of much decision-support software. Building on the basic methods from the operations research courses, we will discuss the benefits and limitations of different modeling and solving techniques, e.g., linear, integer and stochastic models, to strategic, tactical and operational level decision making, and examine the most successful recent work from real life applications in detail. While doing so, we will follow primarily a practical spreadsheet-based approach to provide hands-on experience with software such as Excel Solver.

Prerequisites: 21-292 or 21-257

70-462 Stochastic Modeling and Simulations

Intermittent: 9 units

This hands-on course on computer simulation of business, service, and manufacturing systems (that are subject to uncertainty or risk) takes the perspective of the consultant whose job is to analyze stochastic decision problems by building a simulation model and using it to understand the behavior of the system and explore the effects of alternative decisions. Two modeling methodologies will be presented: 1) Models, both static and dynamic, that can be implemented as mathematical expressions in a spreadsheet; and 2) discrete-event models that utilize the event scheduling formalism. @Risk, from Palisade Corporation, is the tool that will be used to demonstrate how to build and execute spreadsheet simulation and Arena, from Rockwell Software, is the tool that will be used to demonstrate how to build discrete-event simulation models for service and manufacturing applications. Upon completion of the course students will be able to carry out the entire process of designing the model, implementing it in the appropriate software, executing the simulation, collecting and analyzing output data, and using the results of the analysis to evaluate alternative decisions.

Prerequisites: 36-220 or 36-201 or 36-207 or 70-207 or 36-225

70-465 Technology Strategy

Spring: 9 units

This course is about business strategy for technology-intensive industries. Examples of such industries are computer hardware and software, media and entertainment, telecommunications and e-commerce. We will explore the unique economic circumstances facing firms in these industries and identify strategies that enable firms to succeed given these circumstances. You will learn to analyze pricing strategies including versioning and bundling; product standardization decisions; managing product complements; exploiting network effects; managing platform competition. This course will help you understand the unique economic characteristics seen in today's technology-intensive markets and how they impact the strategic interactions among firms and consumers. We will study, for example: Why firms in the IT industry give away their best products for free. Why makers of video gaming consoles subsidize end users (but tax game developers) while computer operating system makers subsidize software developers (but overcharge end users). Why Sony won the Blu-Ray format war against HD-DVD which was sponsored by a whole array of companies. In order to understand how firms strategically interact with consumers in technology-intensive industries this course will use a combination of simple but rigorous analytical models, emerging theories, and formal case studies.

Prerequisites: 21-120 and (21-256 or 21-259) and 73-100 and 73-230

70-471 Supply Chain Management

Fall: 9 units

During the course we will discuss the basic issues of Supply Chain Management like inventory management, risk pooling, network planning, and supply contracts as well as some of the more concurrent issues. In the face of a globalizing economy we will discuss procurement and outsourcing strategies, global logistics and risk management. As supply chains generally cross firm boundaries we will look at supply chain integration, and alliances from a supply chain perspective. Also, as more and more information can be gathered about customers you will learn how to judge the value of this information and whether or not one should adopt a customer specific pricing model. The above issues will be covered at a general strategic level but whenever possible you will also learn how to quantitatively make trade-offs between alternatives.

Prerequisite: 70-371

70-474 Quality Management and Productivity

Fall and Spring: 9 units

We will first compare and contrast the ideas of various quality "gurus," examining ways to define and measure quality. In most cases, the goal should be to design and maintain a process which is in statistical control, producing with the "best" nominal value, and with a minimum of variation. How to determine what is "best" is a topic which we will also discuss; we will explore the use of the Taguchi Loss Function to help answer this question. We will also consider issues surrounding successful adoption of quality initiatives & finding ways of improving quality but being unable to get anyone to implement them is a prototypical problem in quality programs. We will then discuss strategies and tools which can be used to try to ensure quality; it is important to not only be familiar with the tools of quality design and control, but also to understand when and how they can best be correctly applied. In this area we will study three central topics & the first two, sampling and control charts, serve as a basis for the correct application and evaluation of the third, design of experiments. These central topics will be illustrated through exercises, experiments, and cases, culminating in a final interactive capstone case for the class. We will conclude with a discussion of six-sigma, exploring its similarities and differences as compared to traditional quality programs. At the conclusion of the course you will understand the six-sigma framework, and be comfortable with its technical tools. Other topics we will consider include process capability, setting tolerances, process control, quality in service operations, evaluatory techniques such as the House of Quality, and ISO 9000 certification. The goal of the course is not to indoctrinate students into any single quality assurance framework, but rather to teach them the techniques that are common, and central, to any effective quantitative quality design and maintenance program.

70-476 Service Operations Management

Intermittent: 9 units

The service sector accounts for approximately 70% of the GDP and 85% of the jobs in the United States. Given the ever-increasing role of services in the economy, it is crucial for a manager to understand both how services differ from manufacturing operations and how traditional operations management techniques can be applied to services. This course provides a general managers perspective on strategic analysis as well as operational decision making. The course will examine settings in traditional service businesses such as financial services (banking), retail environments, and transportation (airlines), and health-care sector. The Additional topics include evaluation of management of service quality, variability and customer waits, and revenue management. The course is intended for students interested in general management, consulting, financial services, or operations.

Prerequisites: (36-202 or 70-208 or 36-208) and 70-371

70-480 International Marketing

Spring: 9 units

This course is designed to provide students with a basic understanding of global marketing opportunities, key issues, and strategies. It introduces the main characteristics of international markets and addresses the impact of global environmental factors (economic, social, legal, and cultural) on marketing decisions such as market entry, product development, pricing, promotion, and distribution. The objective of the course is to help students acquire knowledge of major international marketing concepts and develop cross-cultural sensitivities and skills that would enable them to identify, analyze, and solve international marketing problems.

Corequisite: 70-381

70-481 Marketing Research

Spring: 9 units

The purpose of this course is to teach multiple research techniques used in marketing. This course is an applied marketing course that gives insight into how various techniques are used in marketing research firms. There are three projects and a final. The first project is designed to teach students about research survey methods. The second is an experiment in which the whole class is involved. The third, an individual project, is designed to teach quantitative research techniques.

Prerequisites: 70-208 or 70-381

70-482 Pricing Strategy

Intermittent: 9 units

Pricing is a critical marketing decision which enables a firm to translate customer value into profit. This course provides a first survey of pricing concepts. Instead of discussing pricing in isolation, we focus on the interplay between pricing and other aspects of marketing, such as positioning, branding and advertising. To this end, we provide a formal treatment of pricing concepts in the framework of game theory. Finally, we also discuss non-pricing tools that firms can use in order to capture customer value. Specifically, we cover cases wherein firms generate a profit while keeping their services free, a phenomena that is widely observed among Internet firms. This course has no formal prerequisite, but a willingness to study formal (i.e., mathematical) models is assumed. Any previous exposure to microeconomics analysis and game theory will be helpful.

70-483 Advertising and Marketing Communications

Intermittent: 9 units

This course is designed to help students develop an integrated marketing communications plan to build enduring brand values. Students will work in groups on developing a MarCom plan for a real company. Several marketing managers of the company will come to class, present background information about the company, and the brand/product that students will be working on. The course contains three parts: 1 — frameworks for brand management used to selecting target audiences and set communications objectives; 2 — the evaluation of alternative creative messages (e.g., youtube videos), testing ad effectiveness, and assessing the effectiveness of the mix as a whole (traditional and non-traditional media); and 3 — non-traditional marketing tools such as social media, viral marketing, and event and guerilla marketing.

Prerequisite: 70-381

70-485 Product and Brand Management

Fall: 9 units

In this course you will progress through a series of roles, from product assistant to group product manager, that give you the opportunity to experience what is like to do product and brand management. Through interactive lectures, case discussions and assignments, you will learn how to conduct analysis and make decisions that face product managers in industry. This course covers consumer and business to business marketing, including brand strategy, new product introduction, pricing and product line profitability, distribution strategy, marketing communications integration, and brand/product portfolio management. Time is also spent on building effective internal, cross-functional and external customer and agency relationships. By progressing through case-based roles from product/brand assistant to group brand/product manager, you will learn the principles of product and brand management and understand what it is like and what it takes to be a successful marketing leader.

Prerequisite: 70-381

70-487 Customer Management Using Probability Models

6 units

Forecasting is a critically important activity for all firms. This course provides simple but powerful models that use readily available purchasing data to capture underlying patterns in customer behavior. More importantly, learn how to use these models to provide accurate forecasts for what these customers will do in the future, as well as the right way to think about modeling customer activity. Using this way of thinking, it is possible to see that consistent behavioral patterns exist across different marketing channels (e.g., offline, online and catalog) and even across seemingly different domains (e.g., grocery and music). The tools are very general in their applications and can also be used for various Decision Analysis applications that manufacturing managers and consultants as well as information technology professionals are often faced with. Prerequisite: 70-381 Student Status: Junior

Prerequisite: 70-381

70-488 Interactive Marketing

Spring: 6 units

In this course we analyze what happens to marketing practice when cheap and powerful computers and communication networks are used to mediate markets. This course focuses on several areas where the presence of computers and networks are likely to have the most profound affect on the field of marketing. These areas include branding, promotion, competitive strategy, channel conflict, pricing and marketing information goods, and identifying and differentiating customers. We will use both lectures, cases, and analysis of real-world datasets to analyze these issues.

Prerequisite: 70-381

70-492 Investment Analysis

Fall: 9 units

Students build a strong foundation in Modern Portfolio Theory as well as equilibrium and no arbitrage approaches to asset pricing. Common stocks and fixed income securities (including mortgage-backed securities) are the principal markets of interest, with tangential coverage of forward, option, and currency markets. Empirical projects entail applications of trading strategies, portfolio management, and the characteristics of financial market data.

Prerequisites: 21-370 or 70-391

70-494 Financial Markets: Anomalies and Efficiencies

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. The purpose of this elective is to offer students the knowledge and understanding to design a portfolio. Applying core theoretical work (that originated from Carnegie Mellon) and current empirical results from academic studies, students will first formulate an investment plan for the regional markets. Working in small teams, students will investigate the applicability of the plan to their subset of stocks as well as apply standard valuation theory. Team results will then be pooled and screened to identify the final set of stocks from which the portfolio will be constructed. This final set of stocks is then used by students to apply the underlying principles of portfolio design including the use of risk management constraints. This part of the course will use Excel's Solver, a flexible constrained optimization tool that students should master. Students will also learn how common metrics (including Value-at Risk), are used to plan and evaluate portfolio performance. The course will culminate with a formal presentation of the investment plan to an advisory board consisting of faculty members (and other relevant members).

Prerequisite: 70-391

70-495 Corporate Finance

Spring: 9 units

Students develop an advanced financial perspective on how firms make investment, financing, and management decisions. The course starts with simple net present value rules and builds the theoretical framework to address more sophisticated issues and problems including risk management, mergers, acquisitions, executive compensation, corporate governance, and dividend payout policies. Theory is supplemented with numerous case study examples.

Prerequisites: 21-370 or 70-391

70-496 Entrepreneurial Finance: Valuation & Deal

Spring: 6 units

This case-based course studies the financing and valuation of high-growth entrepreneurial firms in the venture capital market. We address the requirements and limitations of a wide array of valuation techniques from the perspective of both the demand and supply side of the market. The entrepreneur's perspective (demand) concerns identifying financing needs and value. The investor's perspective (supply) requires the use of a set of tools to evaluate, structure and price financing deals. The tools include discounted cash flow, the VC method, comparables analysis and real options. Venture capitalists act as financial intermediaries and provide both capital and guidance to entrepreneurial firms. These facts introduce unique twists on valuation and deal selection. The course will include four cases over the mini which require group work, class participation and group presentations.

Prerequisite: 70-391

70-497 Derivative Securities

Fall: 9 units

In this course students will learn how to price derivative securities such as futures, options, volatility derivatives and credit default swaps. In addition to covering canonical valuation formulae, students will use numerical simulation methods. The course will also cover various aspects of using derivative securities for risk management purposes. The emphasis of the course lies in solving practical applications using Excel.

Prerequisites: 21-370 or 70-391

70-499 Internship

Fall and Spring

BA students are strongly encouraged to undertake internships. Students doing an internship of an academic nature do so under the supervision of a faculty member and receive a letter grade. Non-academic internships are possible for pass-fail credit with the approval of the Department Director. Enrollment by permission of the BA Program.

70-500 Honors Thesis I

Fall

Business students with outstanding academic records may undertake an Honors Thesis. The topic is of the student's choice but must have some original aspect in the question being explored, the data set, or in the methods that are used. It must also be of sufficient academic rigor to meet the approval of a faculty advisor with expertise in the project's area. Students enroll each semester in a 9-unit independent study course with their faculty advisor for the project (70-500 in the fall and 70-501 in the spring). Students and their faculty advisor develop a course description for the project and submit it for approval as two 9-unit courses to the BA department. Enrollment by permission of the BA Program.

70-501 Honor Thesis II

Spring

Business students with outstanding academic records may undertake an Honors Thesis. The topic is of the student's choice but must have some original aspect in the question being explored, the data set, or in the methods that are used. It must also be of sufficient academic rigor to meet the approval of a faculty advisor with expertise in the project's area. Students enroll each semester in a 9-unit independent study course with their faculty advisor for the project (70-500 in the fall and 70-501 in the spring). Students and their faculty advisor develop a course description for the project and submit it for approval as two 9-unit courses to the BA Director. Enrollment by permission of the BA Program.

70-502 Independent Study in Management

Fall and Spring

Students with a special interest in Management/Production not covered by a formal Business course may develop an Independent Study Course in that area. Readings and work to be completed are by agreement between the student and an individual faculty member. Enrollment by permission of the BA program.

70-503 Independent Study in Marketing

All Semesters

Students with a special interest in Marketing not covered by a formal Business course may develop an Independent Study Course in that area. Readings and work to be completed are by agreement between the student and an individual faculty member. Enrollment by permission of the BA Program.

70-504 Independent Study in Organizational Behavior

All Semesters

Students with a special interest in Organizational Behavior not covered by a formal Business course may develop an Independent Study Course in that area. Readings and work to be completed are by agreement between the student and an individual faculty member. Enrollment by permission of the BA Program.

70-505 Independent Study in Finance

All Semesters

Students with a special interest in Finance not covered by a formal Business course may develop an Independent Study Course in that area. Readings and work to be completed are by agreement between the student and an individual faculty member. Enrollment by permission of the BA Program.

70-506 Independent Study Management Information Systems

All Semesters

Students with a special interest in Management Information Systems not covered by a formal Business course may develop an Independent Study Course in that area. Readings and work to be completed are by agreement between the student and an individual faculty member. Enrollment by permission of the BA Program.

70-507 Independent Study in Business Communications

All Semesters

Students with a special interest in Business Communications not covered by a formal Business course may develop an Independent Study Course in that area. Readings and work to be completed are by agreement between the student and an individual faculty member. Enrollment by permission of the BA Program.

70-508 Independent Study in International Management

All Semesters

Missing Course Description - please contact the teaching department.

70-514 Independent Study: Graphic Media Management

Fall and Spring

This course enables students to independently pursue special topics related to graphic media. Enrollment is by permission of the Instructor and the Executive Director of the Business Administration program. Formerly course number 70-650.

CFA Interdisciplinary Courses

62-010 Pittsburgh Filmmakers

Fall and Spring: 9 units

Any of Pittsburgh Filmmakers full semester course offerings are available for registration through the CFA Dean's Office. Visit www.pfm.edu for listings. Registration can only be done on or after your scheduled registration day. Spaces are limited. Stop by CFA 100 for details and to register.

62-102 Modern Dance Workshop

Fall and Spring: 6 units

A modern dance class based on the philosophy of the Martha Graham technique. The class is designed to encourage exploration and discovery of the roots of physical movement and control. The class also covers fundamental and technical aspects of modern dance as a classical performing arts form.

62-110 Passport to the Arts

Fall and Spring: 9 units

Exploring Audience and Ideas in the Arts: "Passport" is an introductory level course that explores the philosophy of aesthetics through direct attendance at performances and exhibitions. The course is constructed in modules that represent each school within the College of Fine Arts (architecture, art, design, drama and music) building toward cross-disciplinary practice. Each module contains a guest lecture, event attendance, and follow-up discussion which serve as points of entry into each discipline as well as points of comparison within the arts as a whole. These three components provide a direct link between theory and practice allowing students to gain a critical vocabulary to discuss their experiences. Outside of class, supplementary readings, audience participation, and written reflections provide an opportunity for students to use course material to enrich their own artistic practice. Ultimately, students are asked to consider their roles as an artist: within their discipline, within the arts, and within the broader community. This course concludes with a final symposium/exhibition of participating students.

62-141 Black and White Photography I

Fall and Spring: 10 units

This course will teach you the basic craft of photography from exposure of the negative through darkroom developing and printing to print finishing and presentation. Content includes student presentations, class discussions, shooting assignments, darkroom sessions and class critiques. We will concentrate not only on the technical aspects of photography, but also the aesthetics of seeing with a camera. The course concentrates on photography as a fine art — what is unique to it and the concerns that are shared with other visual arts, such as composition, tonal values, etc. and aims to equip students with an understanding of the formal issues and the expressive potentials of the medium. Lab fee and 35mm manual camera required. Each student is responsible for the cost of paper and film.

62-142 Digital Photography I

Fall and Spring: 10 units

This course explores digital photography and digital printing methods. By semester's end students will have knowledge of contemporary trends in photography, construction (and deconstruction) of photographic meaning, aesthetic choices, and the use of color. Students will learn how digital cameras work, proper digital workflow, RAW file handling, color management and Adobe Photoshop. Through the combination of the practical and theoretical, students will better define their individual voices as photographers. No prerequisites.

62-150 Introduction to Media Synthesis and Analysis

Fall: 10 units

[IDeATe portal course] New creative industries are empowering new modes of collaborative consumption, creation and reuse of media. This often relies on successful collaborations between cross-trained artists, designers and technologists as well as critical reflection on distribution, participation, interaction and audience. This course is designed to prepare engineers and scientists to work in these contexts. By the end of the course, students will be able to think critically across several media theory paradigms; formulate the intent of their creative work; articulate relationships to art/design practice and theory; and respond insightfully to creative outcomes. The goal is not just to make creative media rich outcomes but also to think critically about their production. Organized as three related 7-week modules, all students will take 'Critical Media Analysis' and can then choose to focus on 'Visual Synthesis' or 'Sound Synthesis'. Modules will introduce core concepts through foundational texts, in-class exercises, collaborative projects, and group critique. Students will ground concepts such as critical design, computational performance, embodiment, emergence, composition, participatory interfaces, and media editing through hands-on, applied exploration. Weekly lab sessions will also support the development of new skills and practical development of digitally mediated content. Please note that there may be usage/materials fees associated with this course

Course Website: <http://www.cmu.edu/ideate/courses/index.html>

62-165 Mutable Landscape:

Intermittent: 10 units

With camera in hand, students will explore, document and invent a sense of place in Pittsburgh. Informed by photographic history and landscape studies, students will develop their own portfolios of digital prints. As a CFA Interdisciplinary photography course, students will be encouraged to consider their photographs in the medium of their home department, and in some cases as a starting point for projects in other materials. No prerequisites.

62-175 Descriptive Geometry

6 units

This is a manual construction course for solving problems in three-dimensional geometry through working with two-dimensional planes using basic mechanical drawing tools. The course covers basic concepts of descriptive geometry; solving problems involving lines and planes in space and their spatial relationships; rotations in three dimensions; locating points and tangents on solids and surfaces; intersection of solids; shades and shadows; perspectives; and development of surfaces.

62-240 Unfolding Environments: The Intersection of Person and Place

Fall and Spring: 10 units

This course will use photography and visual narratives to look at our surroundings. Assignments will focus on image sequencing and editing, combining the practices of portraiture, landscape, still life and observational photography to create narrative work that explores the complex connections between people, objects and the spaces they inhabit. Through the semester, students will strengthen their understanding of the ways in which these tangible and abstract elements of our environments work together, while also developing their technical abilities by working with color and black and white images, natural and artificial lighting and digital workflow. The course will explore the medium's history and contemporary practice through class presentations and the study of work and books by notable and emerging figures in the medium, including Robert Adams, Rineke Djikstra, Carolyn Drake, Wayne Lawrence, Milton Rogovin, Judith Joy Ross, Michael Schmelling, Stephen Shore, Alec Soth, Zoe Strauss, Larry Sultan, Carrie Mae Weems and Susan Worsham. Discussions, readings, studio visits and critiques will provide an outline for completing assignments.

62-241 Black and White Photography II

Fall and Spring: 10 units

This course extends the traditional darkroom process of silver printing from Black and White Photography I, with an emphasis on aesthetic development, personal artistic growth, and formal image evaluation. Skills covered include medium and large format cameras, advanced darkroom printing techniques, exhibition presentation, and film scanning for inkjet output. Studio work involves both group critique and individual direction from the instructor. Students should expect to produce a finely-printed body of work by the end of the semester. Prerequisites: 62141 or 60141 or 51265 or consent of instructor.

Prerequisites: 60-141 or 51-265 or 62-141

62-245 Portrait Photography

Intermittent: 10 units

Portrait Photography explores the emotional and visual process of collaboration between subject and photographer that creates a photograph. We'll use cameras of all formats and levels of sophistication to create portraits in the studio and on location. We'll find and exploit available light and create artificial light to complete our vision, and we'll explore a wide range of darkroom strategies to support and add richness to our final print. Through film and video we'll meet some of the masters of this form like Arbus, Newman, Avedon and Penn, and we'll take advantage of any opportunities to visit exhibitions and photographers studios. Lab fee required. Prerequisites: As listed or consent of instructor.

62-247 Introduction to Hot Glass I

Fall and Spring: 3 units

In this introductory Hot Glass I class, you will learn to gather molten glass from the furnace, and then shape it into various forms from paperweights to simple blown shapes such as cups and bowls in clear glass. The instruction will focus on a team approach to glassblowing, with an emphasis on safety, proper tool use, basic techniques, and materials. You'll never drink from a glass again without appreciating what went into making it! This class is appropriate for students with limited or no hot shop experience. You may also wish to take this class a second time in order to continue to develop and refine basic skills before moving on to Hot II. The class fee includes 1 hour of open studio time per student (2 hours with a partner), so that students can become familiar with the studio and learn the simple process of studio rental outside of class hours. Each time you take it, you will gain confidence and skill as your passion for glass grows. Registration for Pittsburgh Glass Center classes can only be done on or after your scheduled registration day. Spaces are limited. Registration is done on a first come, first served basis. Please go to CFA 100 to register. Course fee is \$287.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-250 Beginner Beadmaking

Fall and Spring: 3 units

If you're fascinated by baubles, bangles and beads, this is the class for you. You will make many glass beads as you learn the basic skills of heating Moretti (soft) glass, applying it to the mandrel, and shaping it with tools. You will learn to make round beads and alter the shape and add decorative color with techniques like encasing, dots, frits, and trails. The class fee includes 2 hours of open studio time per student, so that students can become familiar with the studio and learn the simple process of studio rental outside of class hours. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$175. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-251 Pendant Passion

Fall and Spring: 3 units

Amaze your family and friends with your new collection of borosilicate (hard) glass pendants. In this 8-week session, students will learn a new design technique every week, from compression, pin wheels, donut holes, mandrel beads and much more. Focus on flame development, gathering glass, color application of dots, stripes and color layers to obtain the desired look of your one of a kind pendant. Great for beginners or those with some flameworking experience with an interest in pendants. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$162.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-252 Marble Madness

Intermittent: 3 units

Learn how to fashion a perfect sphere in soft Italian glass. You will begin with the basics of gathering and shaping the ball. Then you will explore a number of techniques to decorate and make various types of marbles from an onion skin, cat's eye, vortex and implosion to name a few. No experience required but more advanced students will also benefit. The class fee includes 2 hours of open studio time per student, so that students can become familiar with the studio and learn the simple process of studio rental outside of class hours. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$175. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-255 Imagery: Powder Printing and More

Intermittent: 3 units

Explore the endless possibilities of the printed image in kilnformed glass. In this class you will learn relief, powder printing and alternative print methods to make rich imagery on glass. We will discuss concept and design while incorporating layering, multiple firings, and basic coldworking to make your pieces. From the abstract to the representational you will leave the class with a number of samples and finished works, as well as the fundamentals to continue printing in your home studio. No previous printmaking experience necessary. The class fee includes 2 hours of open studio time per student, so that students can become familiar with the studio and learn the simple process of studio rental outside of class hours. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to register. Spaces are limited. Course fee is \$217.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-256 Introduction to Coldworking

Fall and Spring: 3 units

Learn about all of the equipment in the cold shop including belt sanders, flat grinders, dremels, lathes, the sandblaster, and the diamond saw. These tools can be used to create intricate patterns and textures on the surface of a variety of glass objects. You will complete several personalized projects. Students with no prior glass experience will be provided items to cold work, but students with existing work they want to refine from other studios are welcome as well. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please register for this course in person at CFA Room 100. Spaces are limited. Course fee is \$122.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-265 Alternative Photo Processes

Spring: 10 units

This experimental photo-printmaking hybrid introduces students to 19th century, non-silver and alternative photographic printing techniques. One-of-a-kind, hand-applied processes include: Van Dyke, cyanotype, salted paper, POP, albumen, platinum & palladium & bromoil. Students will produce large format imagery by use of traditional large format shooting, analogue negative enlarging and/or digital negative methods. In addition to the printing techniques, the class considers how to unite process with concept.

Prerequisites: 51-265 or 62-141 or 60-141

62-275 Fundamentals of Computational Design

Fall and Spring: 9 units

TBA

62-306 Music-Cinema-Culture

Fall: 9 units

The first 100 years of the 20th Century's only original art form, whose advent has brought about tremendous social and cultural changes. Students view selected films, learning first the basics of film theory, cinema's working structures and the function of music soundtrack. Ultimately, they are able to analyze in written essays and class discussions, the function and value of the music in a particular film and the cultural impact such music has had on society. The work of the course involves attendance at screening and active participation in the following analytical discussions. Students are expected to present two reports on films/readings and sustain a final oral presentation.

62-325 View Camera

Intermittent: 10 units

The nature of a 4x5" view camera alters both the process of making a photograph and the qualities of the resulting image. The slow, even cumbersome, process of photographing with a large format camera encourages a methodical, studied approach. The larger negative size and the ability to control the exposure and development of each sheet of film make possible an image of extraordinary clarity and detail. Through a series of exercises followed by a self-selected project, students in this class will learn the technical aspects, and master the use of, the view camera. Topics include: perspective and focal plane control, bellows extension factor, and basic B&W sheet film handling and processing. Students should enter this course already possessing a working knowledge of photographic processing and printing. Prerequisites: 62-141 and any 200 level photo course or consent of instructor.

Prerequisites: 62-245 or 62-241 or 62-205 or 62-141 or 62-265 or 62-381 or 62-337 or 62-326

62-326 Photographic Narrative

Intermittent: 9 units

Most photographs tell stories. We see photographs in newspapers, magazines, snapshot albums, on the web, in books, and in posters. In these contexts photographs often work with words to convey meaning, whether they are shown with captions, news stories, or just with titles. Photographs can work without words, too, to create purely visual narratives. In this course, students will make two series of photographs: one that is fiction and one that is non-fiction. In addition to making photographs, students will determine the context in which their photo-stories will be seen. Students may make photo books, for example, or decide that their images will be seen on a website. While students are making photographs, we will explore the rich traditions of photo-graphic story-telling that range from the world-oriented work of photo-journalist W. Eugene Smith to the documentarians such as Walker Evans, Nicholas Nixon, and Alec Soth. We will look at photographers, too, who constructed private worlds, such as Duane Michals, Cindy Sherman, Bruce Charlesworth, and Laurie Simmons. As students explore both fiction and non-fiction through photographs, we will look at the interesting interplay between words and photographic images; how images are paced and scaled to create tempos; how photographs are sequenced to tell stories; and other formal elements involved in creating visual narratives. Prerequisite: a college level photography course or consent of instructor. Prerequisites: 62-141 or 60-141 or 51-134

62-330 Filmothea: Seminar in Film Music

Summer: 9 units

The first 100 years of the 20th Century's only original art form, whose advent has brought about tremendous social and cultural changes. Students view selected films, learning first the basics of film theory, cinema's working structures and the function of music soundtrack. Ultimately, they are able to analyze in written essays and class discussions, the function and value of the music in a particular film and the cultural impact such music has had on society. The work of the course involves attendance at screening and active participation in the following analytical discussions. Students are expected to present two written reports on films/readings and sustain a final oral presentation.

62-347 Hot Glass II

Fall and Spring: 3 units

Now that you're hooked on hot glass, how do you keep the momentum going? By enrolling in Hot II, you will become more proficient working with glass. Refine and vary the cup and bowl shape in the first few weeks before moving on to more complex shapes. Explore basic methods of color application and learn how to troubleshoot common problems. The class fee includes 1 hour of open studio time per student (2 hours with a partner), so that students can become familiar with the studio and learn the simple process of studio rental outside of class hours. Hot I, 24 hours experience, or permission of the instructor required. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$287.50. Not eligible for PCHE cross registration. Course taught at the Pittsburgh Glass Center. Prerequisite: 62-247

62-358 Art and Biology

Intermittent: 9 units

A studio-laboratory art-making course designed to explore interactions between art and biology. It is an opportunity for students interested in interdisciplinary concepts to work both in a studio art environment and a biological laboratory. Students have the opportunity to experiment creatively with scientific media such as electron and video-probe microscopy.

62-360 Photographers and Photography Since World War II

Spring: 9 units

Invented in 1839, photography was a form of visual expression that immediately attracted a large public following. Starting around 1900, photography was practiced with two dominant strands. One of these firmly believed in the power of photographs to provide a window on the world, and was led by Lewis Hine, whose documentary photographs for the National Child Labor Committee helped to ameliorate living and working conditions for thousands of immigrant children. The other strand adhered to the philosophy of Alfred Stieglitz who adamantly affirmed that photographs were first and foremost reflections of the soul and were art objects, equal to painting, drawing and sculpture. These two schools of thought guided photographers throughout the twentieth century. This course explores in depth the tremendous range of photographic expression since World War II and examines in particular the contributions of significant image-makers such as Helen Levitt, W. Eugene Smith, Robert Frank, Diane Arbus, Garry Winogrand, Charles "Teenie" Harris, Cindy Sherman, Carrie Mae Weems, Nan Goldin, James Nachtwey, and many others. Classes include a slide lecture, student presentation, and video segments that introduce a focused selection of images by major photographers in an attempt to understand their intentions, styles, and influences. In Spring 2015, students will be expected to make one or more visits to Carnegie Museum of Art to view Storyteller: The Photographs of Duane Michals, an internationally recognized living photographer who is being celebrated this year with this retrospective exhibition.

62-361 Trajectories in Photography: From its Prehistory to 1945

Fall: 9 units

This course explores the development and practice of photography in relation to the massive social and political changes of the 19th and early 20th centuries. Topics will address modernity's embrace of the visual: photography's role in the rationalization of geographies and peoples; the promises of photography as a new technology; the position of photography in relation to developments in art; the emergence of photojournalism and documentary photography and the use of photography for advocacy; photography in relation to mass media; the photography of spirits and costumed animals. The course draws from various disciplinary perspectives including art history, anthropology, history, and science and technology studies. The course will include instructor lecture and student presentation. Class discussion will be an integral aspect of the class. No prerequisites.

62-371 Photography, The First 100 Years, 1839-1939

Fall: 9 units

Photography was announced to the world almost simultaneously in 1839, first in France and then a few months later in England. Accurate "likenesses" of people were available to the masses, and soon reproducible images of faraway places were intriguing to all. This course will explore the earliest image-makers Daguerre and Fox Talbot, the Civil War photographs organized by Mathew Brady, the introduction in 1888 of the Kodak by George Eastman, the critically important social documentary photography of Jacob Riis and his successor, Lewis Hine, the Photo-Secession of Alfred Stieglitz, the Harlem Renaissance of James VanDerZee, the precisionist f64 photographers Ansel Adams, Imogen Cunningham, and Edward Weston, and other important photographers who came before World War II. The class will be introduced to 19th century processes, such as the daguerreotype, tintype, and ambrotype, as well as albumen prints, cyanotypes, and more.

62-375 Large Format Photography: The Antiquarian Avant-Garde

Intermittent: 10 units

This course takes part in the anti-digital movement by exploring the roots of photography. Students will shoot with an array of large format cameras and use 19th and 21st century processes to create one-of-a-kind photographic imagery. Course topics include view camera techniques, experimental printing processes, pinhole camera-less photography, and contemporary tints. Prerequisites: As listed or equivalent or consent of instructor. Prerequisites: 62-141 or 60-141

62-420 Aesthetics and Critical Judgement

6 units

In this course, we will examine the question of how one judges a work of art. The course will provide an overview of the history of aesthetics in the Western tradition, and in the process we will examine the central questions of: defining beauty, evaluating the artistic object, determining what external factors are relevant to aesthetic judgments (time, culture, biography), and analyzing the inter-relationships between artist, audience, and artistic object. Beyond the knowledge gained, course objectives will include the cultivation of analytical skills in evaluating artistic expression and aesthetic theory, and the development of expository writing and speech skills in aesthetic analysis.

62-442 All about the Pattern

Intermittent: 3 units

In this class we will introduce multiple color techniques to help you learn how to create uniquely patterned glass. Students will learn a variety of pattern bar techniques and also harness the heat of the vitroglyph to create a host of fused platters or decorative wall hangings. Students will be allotted a small color credit to their PGC account in order to become familiar with the simple procedure of purchasing materials for studio rental outside of class. Introduction to Fusing and Slumping or 24 hours of fusing experience with permission of the instructor is required. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$217.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-443 Intermediate Fusing

Intermittent: 3 units

We will focus on perfecting our glass cutting skills and knowledge while revisiting ideas and techniques from introduction to fusing and slumping. Students will learn new ways to make their work unique by exploring color, creating their own art glass and being introduced to pattern bars while continuing to explore the scientific properties of glass and why it behaves the way it does. Students will be allotted a small color credit to their PGC account in order to become familiar with the simple procedure of purchasing materials for studio rental outside of class. Introduction to Fusing and Slumping or 24 hours of fusing experience with permission of the instructor is required. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$217.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-444 Scratch the Surface: Color Techniques

Intermittent: 3 units

Immerse yourself in a world of endless techniques of color applications. Students will begin building a solid foundation in flameworking while focusing on wrap & rake, pin-wheel designs, dot stacks and much, much more. While growing comfortable behind the torch a number of items will be made: marbles, pendants and small sculptures. Join us & get your creative juices flowing! Students will be allotted a small color credit to their PGC account in order to become familiar with the simple procedure of purchasing materials for studio rental outside of class. Flame I, 24 hours experience or permission of the instructor required. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$175. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-445 3D Stained Glass

Intermittent: 3 units

Add some dimension to your stained glass! Students will learn how to cut and shape sheet glass soldering them together to create a 3-dimensional star and set of decorative boxes. No previous experience necessary. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$217.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.

62-446 Hot Glass III

Fall and Spring: 3 units

In this class, you will be encouraged to focus on techniques that interest you as a developing glass artist while still receiving direction and support to refine basic skills and methodology. Learn about a broad range of more complicated techniques including use of solid color, mold-blowing, and compound shapes as you create unique vessels. This class can be repeated as content will vary by session. 48 hours hot glass class/workshop experience, or permission of the instructor required. Basic materials provided and students will be allotted a small color credit to their PGC account in order to become familiar with the simple procedure of purchasing materials for studio rental outside of class. Registration takes place in CFA 100 on or after your scheduled registration day. Space is limited. Registration is first come, first served. Course fee is \$287.50. Classes are taught at Pittsburgh Glass Center
Prerequisite: 62-347

62-447 Hot Glass III Open Projects

Fall and Spring: 3 units

There will be no weekly demonstration by the instructor. Students in this class will be encouraged to pursue their own ideas and maximize the available work time each week. Students should come to class with projects in mind and questions for the instructor. 48 hours hot glass class/workshop experience required, or by permission of the instructor. Basic materials provided. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$287.50. Not eligible for PCHE Cross Registration. Course taught at the Pittsburgh Glass Center.
Prerequisite: 62-347

62-450 Flame I

Fall and Spring: 3 units

A great combination class to explore variety in the flameshop. You will work with both Moretti (soft) and Borosilicate (hard) glass while learning the fundamentals of flameworking. Begin with a solid rod of glass, melt it into a molten ball to create and manipulate little treasures in the flame such as beads, pendants, marbles and sculptures. Over the course of 8 weeks color application, hand control and annealing will be covered, as well as one on one troubleshooting. The class fee includes 2 hours of open studio time per student, so that students can become familiar with the studio and learn the simple process of studio rental outside of class hours. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course fee is \$175. Not eligible for PCHE cross registration. Course taught at the Pittsburgh Glass Center.

62-452 Flame II

Fall and Spring: 3 units

Fine-tune your skills from Flame I while taking it to another level! In Flame II things begin to flow more naturally, hand and glass control, multi-tasking while remaining in one spot. Borosilicate tubing will be introduced and a number of exercises will be taught to become more skilled working with tubing. Students will work independently with one-on-one demonstrations, find your focus and push the limits. Students will be allotted a small color credit to their PGC account in order to become familiar with the simple procedure of purchasing materials for studio rental outside of class. Flame I, 24 hours experience or permission of the instructor required. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. There is a \$175 Course Fee. Spaces are limited. Not eligible for PCHE Cross-Registration. Course taught at the Pittsburgh Glass Center.

62-453 Introduction to Fusing and Slumping

Fall and Spring: 3 units

Fusing has many dimensions even though you are working with flat glass. Harness the heat of the kiln and use a wide spectrum of glass materials to create an array of functional works of art. By exploring multiple techniques including the difference between full and tack fuses, kiln carving, mosaics, faux murrini and strip cutting, you will be comfortably fusing in no time. Kiln theory, glass compatibility, bubble control, kiln programs, cold working and more will be covered. The class fee includes 2 hours of open studio time per student, so that students can become familiar with the studio and learn the simple process of studio rental outside of class hours. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course Fee is \$217.50. Not eligible for PCHE cross registration. Course taught at the Pittsburgh Glass Center.

62-455 Intro to Kiln Casting

Fall and Spring: 3 units

Combine sculpting and building molds of objects with the heat of the kiln to manipulate glass and create glass cast tiles and sculptures! You will be introduced to the art of kiln casting through the creation of small 3D objects including sculptures and non-functional vessels using a variety of mold making and casting techniques. This class will cover constructing molds, making refractory molds, preparing the glass, firing the molds in kilns and resolving castings into finished works of art. We will also go over rubber molds and found object casting! Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please go to CFA 100 to sign up. Spaces are limited. Course Fee is \$217.50. Not eligible for PCHE cross registration. Course taught at the Pittsburgh Glass Center.

62-456 Fused and Slumped Glass-Phase II

Fall and Spring: 3 units

We will focus on perfecting our glass cutting skills and knowledge while revisiting ideas and techniques from introduction to fusing and slumping. This class will focus on your ideas and desired finished projects while raising the caliber of work you create. New techniques will be discussed as student designs require. 24 hours of fusing class/workshop experience required, or permission of the instructor required. Basic materials provided. Registration can only be done on your scheduled registration day and is done on a first come, first serve basis. Please register in person at CFA 100. Spaces are limited. Course Fee is \$205. Not eligible for PCHE cross registration. Course taught at Pittsburgh Glass Center. Prerequisite: 62-453

62-459 Intro to Stained Glass

Fall and Spring: 3 units

Learn the Tiffany method of stained glass while creating your very own stained glass panel from a variety of patterns and glass. Students will learn the basic skills of cutting and shaping sheet glass, foiling and soldering. An understanding of these skills is critical to success and by the end of the class you will feel confident to continue with your new found art form. Registration can only be done on or after your scheduled registration day. Please stop by CFA 100 to register. Registration is first come, first served. Course fee is \$217.50. Class is held at Pittsburgh Glass Center.

62-464 Earring Clinic with Michael Mangiafico

Intermittent: 3 units

Explore the world of mandrel flameworked hanging style glass earrings through melting colorful soda lime glass that was manufactured in Italy. We will explore, make and incorporate traditional Venetian Zanferico that's fancy glass canes into delicate ornaments for the ears. Pursue the anatomy of a well-proportioned earring all the while playing with sparkly dichroic coated glass and learning how to put together a good loop for the pendant.

62-473 Print/Photo Workshop

Intermittent: 10 units

TBA

62-475 ACTIVATED ANAMORPHS: Performative Inhabitables and Interactive Prostheses

Fall and Spring: 10 units

This interdisciplinary project and performance based studio course will concentrate on the contemporary relationship between wearable sculpture, prosthetic apparatus, DIY costume, and identity-based performance. Class time will be spent designing and fabricating performative devices that alter, augment, mask, and transform the body and its inherent abilities. Guest instructors from across the College of Fine Arts will provide lectures, critique, and workshops to offer students multiple perspectives and techniques. Students will work in a variety of media, unveiling the meanings expressed through materials and investigating new ways to interact with our physical environment through explorations in the adaptation, translation, enhancement, exaggeration, modification, and mutation of the human body. The course will involve student collaboration across disciplines, as well as rehearsals and public performances through its connection to the wats:ON Festival. Open to third year/ juniors and above. Faculty: Scott Andrew Consulting Faculty: Spike Wolff Instructional Team: Narelle Sissons, School of Drama Susan Tsu, School of Drama Scott Andrew, School of Art Josh Reiman, School of Art Tom Merriman, School of Design Michele de la Reza, School of Music Peter Kope, School of Music Jesse Stiles, School of Music, IDeATe Nina Barbuto, School of Architecture Spike Wolff, wats:ON Festival Curator

62-478 digITool

Fall and Spring: 6 units

This IDeATe-affiliated course serves as an introduction to the fundamental concepts, processes, and procedures to utilize digital and traditional equipment within the IDeATe@Hunt Library facilities. After completion, participating students should leave with a thorough understanding of laser cutting/engraving, 3D printing, CNC routing, and traditional woodworking equipment/processes; and how to operate in a safe, responsible, and efficient manner. This comprehension and experience proves useful for all creative disciplines, and participants are certified for future fabrication equipment access. This course will be divided into (2) groups: group [A] will meet on Mondays and Wednesdays. Group [B] will meet on Mondays and Fridays.

62-483 Growing Theatre Community Outreach

Fall and Spring: 6 units

Growing Theater engages students and mentors in the development of a collaborative theater experience. Through Mentor Role Modeling, Growing Theater uses drama as a medium to expose at risk population of fifth graders from a local school to a supportive learning environment that is shared, creative, confident, patient and respectful. Growing Theater Mentors will broaden students' personal and professional outlooks by guiding through them this theatrical process. The resulting play is performed in May at CMU. This course is open to all students, not just Drama majors.

62-661 Interaction and Expression using Pausch Bridge Lighting

3 units

Working in cross-disciplinary teams, students will explore light as art, interactive design and programming using a Pharos lighting control system. Students will explore the use of light and interaction using the actual controls within the Randy Pausch Memorial Bridge. Student teams will develop final projects that will be exhibited on the actual Randy Pausch Memorial Bridge.

62-714 Galleries & Auction Houses: Economics of the Art Market

6 units

This class surveys the for-profit art gallery model. Topics include exploration of the business model and common practices of for-profit art galleries and the primary and secondary markets for art sales. Art Appraisals auctions and auction galleries artist procurement art collectors and investor cultivation as well as a profile of gallerists will be discussed in detail. Students will be required to work an art auction and attend the opening receptions for local exhibitions. There will be a non-required trip to the gallery districts of New York City to visit galleries and talk to gallery directors and staff. Corporate art collections will also be discussed as well as how to set prices artist commissions artist agreements consignment sales and inventory will also be topics covered by this course.

62-775 ACTIVATED ANAMORPHS: Performative Inhabitables and Interactive Prostheses

Fall and Spring: 10 units

This interdisciplinary project and performance based studio course will concentrate on the contemporary relationship between wearable sculpture, prosthetic apparatus, DIY costume, and identity-based performance. Class time will be spent designing and fabricating performative devices that alter, augment, mask, and transform the body and its inherent abilities. Guest instructors from across the College of Fine Arts will provide lectures, critique, and workshops to offer students multiple perspectives and techniques. Students will work in a variety of media, unveiling the meanings expressed through materials and investigating new ways to interact with our physical environment through explorations in the adaptation, translation, enhancement, exaggeration, modification, and mutation of the human body. The course will involve student collaboration across disciplines, as well as rehearsals and public performances through its connection to the wats:ON Festival. Open to graduate students. Faculty: Scott Andrew Consulting Faculty: Spike Wolff Instructional Team: Narelle Sissons, School of Drama Susan Tsu, School of Drama Scott Andrew, School of Art Josh Reiman, School of Art Tom Merriman, School of Design Michele de la Reza, School of Music Peter Kope, School of Music Jesse Stiles, School of Music, IDeATe Nina Barbuto, School of Architecture Spike Wolff, wats:ON Festival Curator

CIT Interdisciplinary Courses

39-100 Special Topics: WHAT IS ENGINEERING?

Fall: 9 units

What is Engineering? In today's world, we are so used to technology, helping us yet giving rise to complex problems, our friend and yet sometimes our challenge in preserving all that is human. This course is an introduction to all students about what engineers do and how they do it. It is about the culture, the thinking, the creativity and more than anything else, the doing which is at the heart of engineering. On a more pragmatic level, our world of ever-increasing technological complexity demands that everyone is to some extent familiar with things technical. William A. Wulf, President of the National Academy of Engineering, has said that a public that is technologically less than literate and unable to understand technical decisions is left to trust that good decisions will be made on their behalf. We invite you to take this course to get a feeling for what engineers experience in their work and bring out the creativity in each of you. The goal of this course is to help Carnegie Mellon students of all disciplines understand the role and impact of engineering in modern society and participate in the excitement of engineering. Demonstrations and hands-on projects will give students the experience of what engineers do. After completing this course you will have a better understanding of the contributions of engineering to our society, how engineers see and think about the world, what the "big issues" for engineers are, what's involved in the different fields of engineering, and the tools engineers use. The multi-disciplinary and collaborative nature of almost all engineering work will be stressed. 39-100 is open to first through third year students in all majors except engineering.

39-200 Business for Engineers

Fall and Spring: 9 units

This course is intended to prepare CIT graduates for the fast paced world of modern industry. There have been paradigm shifts that complicate career selection and compound the difficulty of becoming a productive member of an organization. Graduates of a technical program can benefit from an understanding of modern business concepts when they begin their careers. The content of this course will include both specific financial analysis topics and certain business administration topics such as program management, entrepreneurship and ethics. Students will become familiar with analyzing financial statements, stock market reports and stock options while developing their verbal and written presentation skills.

39-210 Experiential Learning I

Fall and Spring

The engineer of the 21st century will need to operate effectively in many settings and often with a global perspective. Being curious and constantly looking for inspiration are critical for lifelong learning. This course, designed for all CIT sophomores, requires the student to choose and experience activities for development and growth that are not part of formal course work. The activities are chosen from a list provided on the CIT Undergraduate Studies website.

39-220 Experiential Learning II

Fall and Spring

The engineer of the 21st century will need to operate effectively in many settings and often with a global perspective. Being curious and constantly looking for inspiration are critical for lifelong learning. This course, designed for all CIT sophomores, requires the student to choose and experience activities for development and growth that are not part of formal course work. The activities are chosen from a list provided on the CIT Undergraduate Studies website.
Prerequisite: 39-210

39-245 Rapid Prototype Design

All Semesters: 9 units

This course provides an introduction to rapid design through virtual and physical prototyping. The class covers the engineering design process, problem solving methods, interdisciplinary team work, current industrial practice, and manufacturing process capabilities. The course emphasizes hands on learning. Sophomores have priority while registering for this course. Juniors and seniors will be put on the waitlist, then released once sophomores have registered.

39-250 CIT Undergraduate Projects

Fall

This course number is to be used for Fall CIT freshman research projects only. Student must complete a CIT Undergraduate Project Approval form (located in Scaife Hall 110) and submit for approval. The form must include a complete description and a signature approval from the research advisor/instructor. If the project is approved, the CIT Undergraduate Studies Office will add the course to the student's fall schedule.

39-251 CIT Undergraduate Projects

Spring

This course number is to be used for Spring CIT freshman research projects only. Student must complete a CIT Undergraduate Project Approval form (located in Scaife Hall 110) and submit for approval. The form must include a complete description and a signature approval from the research advisor/instructor. If the project is approved, the CIT Undergraduate Studies Office will add the course to the student's fall schedule.

39-310 Experiential Learning III

Fall and Spring

The engineer of the 21st century will need to operate effectively in many settings and often with a global perspective. Being curious and constantly looking for inspiration are critical for lifelong learning. This course, designed for all CIT juniors, requires the student to choose and experience activities for development and growth that are not part of formal course work. The activities are chosen from a list provided on the CIT Undergraduate Studies website.
Prerequisite: 39-220

39-320 Experiential Learning III

Fall

The engineer of the 21st century will need to operate effectively in many settings and often with a global perspective. Being curious and constantly looking for inspiration are critical for lifelong learning. This course, designed for all CIT juniors, requires the student to choose and experience activities for development and growth that are not part of formal course work. The activities are chosen from a list provided on the CIT Undergraduate Studies website.

39-399 Special Topics: Land Revitalization in the New Global Economy

Spring: 3 units

In this seminar course, we will explore the US process for land revitalization and compare it to the causes and remedies found in China. The results will provide context for a better understanding of global land management challenges that require a balance between the culture, the economy and the environment. The centerpiece of the course is a spring break, 9-day trip to China, visiting the cities of Hong Kong, Shenzhen and Guangzhou, while hearing from local academics and practitioners that are working on land revitalization projects. Students will participate in pre- and post-trip lectures (with some required reading) and will submit a final paper summarizing the regulatory and cultural differences between the US brownfield development process and the sites visited in China. There are no prerequisites. The course is open to juniors, seniors and graduate students and is most pertinent to students in civil and environmental engineering, public policy, architecture, and land use planning.

39-447 CIT Undergraduate Interdisciplinary Design Project

All Semesters

39-447 CIT Undergraduate Interdisciplinary Design Project 3-24 units
This course is to be used for undergraduate research projects involving a significant interdisciplinary design component. It can be added by permission only through collaboration with the student, project advisor, and the CIT Dean's Office. For projects that are not interdisciplinary in nature, students should refer to the research number specific to the department in which the research is being completed.

39-499 Summer Curricular Practical Training

Summer: 3 units

The college of engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is an internship, normally completed during the summer. Students do not need to officially register for an internship unless they want it listed on their official transcripts. CIT students interested in registering their internship for course credit on their transcript may enroll in this course. To do so, students must complete a CIT Internship form (located in Scaife Hall 110) and submit for approval. The CIT Undergraduate Studies Office will add the course to the student's schedule, and the student will be assessed tuition for 3 units. Upon completion of the internship, students must submit a 1-2 page report of their work experience, and a 1-2 page evaluation from the company supervisor to the CIT Undergraduate Office. After the reports has been reviewed and approved, a "P" grade will be assigned. This process should be used by international students interested in Curricular Practical Training (CPT) or by any other engineering undergraduate wishing to have their internship experience reflected on their official University transcript. International students should also be authorized by the Office of International Education (OIE). More information regarding CPT is available on OIE's website.

39-500 Honors Research Project

All Semesters

Juniors who have an accumulated QPA of at least 3.5 receive an invitation to participate in the program. This course, open by invitation only, will provide the opportunity for close interaction with a faculty member through independent honors research in a number of disciplinary and interdisciplinary areas, as part of the CIT Honors Research Program. Students will work on their projects during their senior year, earning the equivalent of 18-24 units. Students are required to register for CIT Honor Research Project 39-500. To receive CIT College Honors, a student must complete at least 18 units in 39-500 on the same research topic. Students are also required to participate in the CIT poster competition at the Undergraduate Research Symposium, "Meeting of the Minds," a university-wide celebration of undergraduate research.

39-600 Integrated Product Development

Fall: 12 units

The IPD course focuses on team-based integrated product development among engineering, business, and design disciplines. The course is open to seniors and graduate students in engineering, industrial and communication design, and MBA students. The course generally has about a dozen students from each discipline. The course consists of four modules including identifying, understanding, conceptualizing and introducing a product opportunity. In recent years we have partnered with industrial sponsors to address a customer opportunity, resulting in patent applications. The emphasis in the course is on the early, "fuzzy" stage of product development. The course gives structure to these stages and helps direct the process to be more efficient downstream. Students are expected to produce four phase written and oral reports. At the end of the semester the team will develop a form prototype, function prototype, marketing plan and manufacturing plan for the product. This course has gained an international reputation as a leading course in new product development. Course admission by permission of professor only; all students will be waitlisted until admission decisions are made. Students should contact the professor for an application for the course.

39-605 Engineering Design Projects

Fall: 12 units

In this project course, students work in multidisciplinary teams to design products or processes. The course is open to juniors, seniors and graduate students from all parts of the campus community. Each project is sponsored by an industry, government or non-profit partner, and is of real commercial interest to that partner. Students work directly with their partner throughout the semester to establish goals and requirements, evaluate their design as it progresses, and produce a final report, presentation, and, if appropriate, a prototype. Design reviews, held twice during the semester, give students a chance to present their preliminary designs and receive feedback and advice. In completing their designs, teams must consider not only the functionality of their designs, but also the look, feel, appearance, and societal impact. Skills built in this course will include: developing the product statement, establishing goals and constraints for the product, project management, and generating and evaluating design alternatives. As some projects may span multiple semesters with new groups of students, careful documentation of project work is emphasized. Students may take this course for either one or two semesters.

39-606 Engineering Design Projects

Spring: 12 units

In this project course, students work in multidisciplinary teams to design products or processes. The course is open to juniors, seniors and graduate students from all parts of the campus community. Each project is sponsored by an industry, government or non-profit partner, and is of real commercial interest to that partner. Students work directly with their partner throughout the semester to establish goals and requirements, evaluate their design as it progresses, and produce a final report, presentation, and, if appropriate, a prototype. Design reviews, held twice during the semester, give students a chance to present their preliminary designs and receive feedback and advice. In completing their designs, teams must consider not only the functionality of their designs, but also the look, feel, appearance, and societal impact. Skills built in this course will include: developing the product statement, establishing goals and constraints for the product, project management, and generating and evaluating design alternatives. As some projects may span multiple semesters with new groups of students, careful documentation of project work is emphasized. Students may take this course for either one or two semesters.

39-647 Special Topics in Design

All Semesters

This course is to be used for Interdisciplinary Engineering Design Independent Study. It can be added by permission only through collaboration with the student, Independent Study project advisor, and the CIT Dean's Office.

39-648 Rapid Design and Prototyping of Computer Science

Spring: 12 units

This course deals with rapid prototyping, manufacture, and applications of a new generation of wearable computers, with head-mounted display. The design of wearable computers is a multidisciplinary process including: Electronic design, mechanical design, software development, and human-computer interaction. Two classes of wearable computers will be further developed: embedded, custom designed VuMan series, and general purpose Navigator series. Electronic design includes the custom designed computer board, electronic interfacing, and power supply. Industrial designers and mechanical engineers team to design and manufacture with in-house facilities a variety of conformable/lightweight housings. A software development environment and user interface builders support software and application development. Current applications include: Global Position Sensing, Hypertext documents, speech recognition, wireless communications, and digital imaging.

39-660 Masters EST&P Project

Fall and Spring

This project course is designed for EST&P students who are working on an independent investigation on a project related to energy with the advice and approval of the program advisor and/or affiliated faculty member. Summary report, presentation or poster on work accomplished must be submitted at completion of semester. Once you have determined a suitable topic area, found an engineering faculty member who has agreed to supervise the project work, send the EST&P project approval form to the EST&P director for enrollment. Variable units. Restricted to EST&P students

39-699 Career & Professional Development for Engineering Masters Students

Fall and Spring: 3 units

This professional development course is designed to engage, educate and empower engineering Masters Students to create and manage career opportunities, as well as to develop the professional skills necessary to be successful in a job search and internship/first year of employment. Open to College of Engineering masters students, this seminar style course will support professional development in the following areas: self-assessment/awareness, resume creation, personal introduction development, job search planning, interviewing, networking, career fair success, entrepreneurship, and internship/employment readiness, etc. Assignments will be actionable and relevant to the job search, enabling students to immediately apply classroom learning. Assignments and active classroom participation will determine pass/fail grade.

Carnegie Mellon University-Wide Studies Courses

99-101 Computing @ Carnegie Mellon

Fall and Spring: 3 units

Computing@Carnegie Mellon (C@CM) is a 3-unit, pass/fail mini course that will help you develop foundational computing and information literacy skills, focusing on the tools and technologies that are specific to Carnegie Mellon so you can be successful in your other academic courses. All undergraduate students are required to take the course. C@CM is offered in a hybrid format through the Open Learning Initiative's (OLI) online course environment; meaning that you'll complete your coursework online and attend a face-to-face recitation session for review and supplemental instruction.

Course Website: <http://www.cmu.edu/c-cm/>**99-102 Computing @ Carnegie Mellon**

Fall and Spring: 3 units

Computing@Carnegie Mellon (C@CM) is a 3-unit, pass/fail mini course that will help you develop foundational computing and information literacy skills, focusing on the tools and technologies that are specific to Carnegie Mellon so you can be successful in your other academic courses. All undergraduate students are required to take the course. C@CM is offered in a hybrid format through the Open Learning Initiative's (OLI) online course environment; meaning that you'll complete your coursework online and attend a face-to-face recitation session for review and supplemental instruction.

Course Website: <http://www.cmu.edu/c-cm/>

99-103 Computing @ Carnegie Mellon

Fall and Spring: 3 units

Computing@Carnegie Mellon (C@CM) is a graduation requirement for all undergraduate students. This 3-unit, pass/fail course is primarily comprised of Carnegie Mellon-specific information. It is intended to help students understand what resources are available as well as their responsibilities as users in our computing community. The course runs for half of the semester and meets twice a week for 50 minutes. Students must pass the course with at least a 75% grade based on exams, homework assignments, a group presentation and attendance. Incoming students are expected to take C@CM during the fall semester. Mini 3 and 4 sections are reserved for spring transfer students and those that did not successfully complete the course previously. There are no test-out options and Advanced Placement, International Baccalaureate or college-level computing courses cannot be substituted for this requirement. C@CM is formerly known as Computing Skills Workshop (CSW).

Course Website: <http://www.cmu.edu/c-cm/>**99-104 Carnegie Skills Workshop**

All Semesters: 3 units

Carnegie Skills Workshop (CSW) is a 3-unit course that helps students to define, locate, evaluate, organize and present information. CSW focuses on essential tools and technologies necessary for the successful completion of research and writing projects assigned in other courses. The same skills are indispensable at any stage in a person's professional career and personal life. All undergraduate students at CMU-Qatar are required to take the CSW course. Incoming students are expected to take CSW during the fall semester.

99-200 Tutoring, Mentoring and Role Modeling--A Community Service Course

Spring: 9 units

99-200 Tutoring, Mentoring and Role Modeling-A Community Service Course

This course has service, intellectual, and personal goals. Its service goal is to provide effective tutors, mentors, and role models to local public school children. Students meet for class once/week and tutor 26 hours during the semester in programs that provide an opportunity to share talents and skills in the community. To promote effectiveness, the course includes topics of tutoring (making tutoring interesting and creative, focusing on meta-learning strategies and study skills); mentoring (exploring multiple mentoring models and the mutual benefits of a mentoring relationship); and informed citizenship (gaining a broader understanding of the issues that urban kids face, exploring how public policies affect the disparities between urban and suburban school student performance. The course also investigates the reasons that "supplemental educational services" are a \$27 billion/year industry in the United States — Why are so many students in need of extra help? Tutors learn that they can be effective in helping younger students, and that it is personally rewarding to do so, and express that it is refreshing to step outside the grind of Carnegie Mellon life and do something meaningful in the community.

99-238 Materials, Energy and Environment

Fall: 9 units

The survival of humans and the advancement of civilization and culture are a result of mankind's continued development of materials. From early times, civilizations with the most advanced materials have dominated the history of warfare and have been responsible for the infrastructural developments that have cradled out societies. As a result, materials have been influential in the trade and commerce between societies and are still to this day, strongly involved in the political, economic and social conflicts worldwide. Materials do not stand alone in development however, they are a result of, or are influenced by, technological needs and developments. The more advanced the material, the more energy and effort is required for its' production. In the US, the production of materials accounts for about 90% of the country's energy usage. This fact clearly indicates a strong tie between materials and energy, and without energy, technological developments based on material advancement will not occur. In our world today, the need to provide improved performance, economics and design in consumer goods comes as a direct result of the market conditions established by consumers. Material selection and design therefore is driven by application and consumer needs which implies that the consumer has a large influence on material consumption. Material selection and material usage in turn have major ecological implications in energy, material resources and direct environmental impact. Awareness of the complicated interaction is paramount for continued development of civilization. With the scale of industrialization that exists on our planet, consideration of resource management, ethical material selection choices, energy management, and final disposal are all necessary to ensure a sustainable future.

99-241 Revolutions of Circularity

Fall: 9 units

In this course we will investigate how the apparently simple concept of circularity (both in stillness and in motion) has accreted meaning. Starting with the circle as presented in early geometry, we will encompass circularity in ancient and Renaissance astronomy as well as classical physics. We will also discuss appearances of the circle in literature, philosophy, and art since our study will reveal connections such as how Aristotle's views on nature influenced Ptolemy and an understanding of our place in relation to the world, including central imagery in the poetry of Donne. As we demonstrate proofs and analyze texts, circularity will emerge not only as a device through which intellectual revolutions have occurred, but also as an object that has itself been transformed over the centuries.

99-242 Meaning Across the Millennia

Spring: 9 units

Is it possible to convey messages that remain comprehensible after immense time, in the face of inevitable cultural shifts and physical decay? In this course, students will come to terms with the technical and philosophical aspects to this problem while working on group projects to propose solutions to the preservation of memory. Along the way, we will identify the challenges in extracting meaning from artifacts, both ancient and contemporary, such as documents and monuments, whether intentional or unintentional. We will also confront ethical and esthetic issues in identifying what is worth preserving, the challenge of societal pressures on past projects, the possibility of future indifference, and the question of what purpose this endeavor may serve for present-day humanity. Case studies will include time capsules such as those created by the Westinghouse Electric & Manufacturing Company for the 1939 and 1964 New York World's Fairs; the proposed warning marker system for the U.S. Department of Energy Waste Isolation Pilot Plant; the Voyager Golden Records launched aboard two interplanetary probes; and attempts at communication with extraterrestrial intelligence.

99-245 Energy: Science, Society and Communication

Spring: 9 units

Energy is a pervasive part of our lives in transportation, industry, agriculture, buildings, and more. However, enormous challenges such as climate change, national security, resource depletion, air and water quality, and biodiversity loss are converging to create an urgent need for broader public understanding of energy development, as well as engagement with related issues. This multi-disciplinary course aims to develop energy-literate students, introduce them to best practices in communicating scientific concepts, and bring them into contact with schools and community organizations as places to further spread the word about energy. In partnership with the National Academy of Sciences (NAS) and National Academy of Engineering (NAE) Science & Engineering Ambassadors program, each week students will meet and interact with different energy-related Ambassadors, including academic researchers, professional engineers, and corporate leaders. Along with exposure to numerous topics in energy sources, production, distribution, and use, students will have an opportunity to discuss the complex problems facing energy policy and infrastructure, and learn about best practices for effective science communication. All students in the course will participate in at least one public outreach session to engage in dialogue with community members, such as secondary-school students, in some aspect of energy and how it relates to their lives.

99-250 Seminar for Peer Tutors

Fall and Spring: 4.5 units

SPECIAL PERMISSION REQUIRED: YES The purpose of this training course is to provide undergraduates with the knowledge, skills, and experience necessary to become effective Peer Tutors. Throughout the course, students will be exposed to the mission and goals of Academic Development and the Peer Tutoring Program. The class lasts approximately nine weeks and is generally offered in the spring term from February through April. The course explores the roles and responsibilities of the tutor while offering insights into effective tutoring strategies through interactive discussion and role plays. In addition, trainees work hands-on with experienced tutors to troubleshoot potential problems and situations. Students will gain experience in group dynamics, communication skills, study strategies, referral resources, leadership, and creating a supportive learning environment. Teaching practice is an integral part of the training program. Students must complete an application in person or electronically at (<http://www.cmu.edu/acadev/studentjobs/index.html>) and then be interviewed by the instructor(s) to determine if the student possesses the basic qualifications.

Course Website: <http://www.cmu.edu/acadev/studentjobs/>

99-251 Seminar for Supplemental Instruction

Fall and Spring: 4.5 units

SPECIAL PERMISSION REQUIRED: YES The purpose of this training course is to provide undergraduates with the knowledge, skills and experience necessary to become effective Supplemental Instruction (SI) Leaders. Throughout the course, students will be exposed to the mission and goals of Academic Development and the Supplemental Instruction Program. The class lasts approximately nine weeks and is generally offered in the spring term from February through April. Course participants will actively explore collaborative learning instructional practices, learning theory, group dynamics, study strategies, and communication and leadership skills in order to create a supportive learning environment. Teaching practice is an integral part of the training program. Students must complete an application in person or electronically at (<http://www.cmu.edu/acadev/studentjobs/index.html>) and then be interviewed by the instructor(s) to determine if the student possesses the basic qualifications.

Course Website: <http://www.cmu.edu/acadev/studentjobs/>**99-252 Seminar for Academic Counseling**

Fall and Spring: 4.5 units

SPECIAL PERMISSION REQUIRED: YES The purpose of this training course is to provide undergraduates with the knowledge, skills and experience necessary to become effective Academic Counselors (AC's). Throughout the course, students will be exposed to the mission and goals of Academic Development and the Academic Counseling Program. The class lasts approximately nine weeks and is generally offered in the spring term from February through April. Students will gain experience in effective and efficient study strategies, learning theory, communication skills, group dynamics, referral resources and how to create a supportive learning environment. Teaching practice is an integral part of the training program. Students must complete an application in person or electronically at (<http://www.cmu.edu/acadev/studentjobs/index.html>) and then be interviewed by the instructor(s) to determine if the student possesses the basic qualifications.

Course Website: <http://www.cmu.edu/acadev/studentjobs/>**99-415 Internship in Educational Outreach**

All Semesters

Missing Course Description - please contact the teaching department.

99-451 Building Fluency for Presentations: A class for nonnative English speakers

Fall and Spring: 4.5 units

Building Fluency for Presentations: A class for nonnative English speakers (NNES) is a 4.5 unit pass/fail mini designed to prepare undergraduate NNES to deliver effective oral presentations. The course will help students become familiar with the expectations of the US style of presenting and will offer opportunities to practice giving presentations on academic topics. Students will focus on developing a broad range of skills, including the ability to: 1) communicate clearly with an audience in academic English; 2) employ linguistic features such as stress, intonation, and nonverbal cues to clarify and emphasize information; 3) consider various organizational strategies; 4) assess speaking strengths and weaknesses; and 5) feel comfortable in the role of presenter. Prerequisite: Permission from the Intercultural Communication Center (ICC). Please call the ICC at 412-268-4979.

Course Website: <http://www.cmu.edu/icc>

Center for the Neural Basis of Cognition Courses

86-375 Computational Perception

9 units

In this course, we will first cover the biological and psychological foundational knowledge of biological perceptual systems, and then apply computational thinking to investigate the principles and mechanisms underlying natural perception. The course will focus on vision this year, but will also touch upon other sensory modalities. You will learn how to reason scientifically and computationally about problems and issues in perception, how to extract the essential computational properties of those abstract ideas, and finally how to convert these into explicit mathematical models and computational algorithms. Topics include perceptual representation and inference, perceptual organization, perceptual constancy, object recognition, learning and scene analysis. Prerequisites: First year college calculus, some basic knowledge of linear algebra and probability and some programming experience are desirable.

86-631 Neural Data Analysis

Fall: 9 units

The vast majority of behaviorally relevant information is transmitted through the brain by neurons as trains of action potentials. How can we understand the information being transmitted? This class will cover the basic engineering and statistical tools in common use for analyzing neural spike train data, with an emphasis on hands-on application. Topics may include neural spike train statistics (Poisson processes, interspike intervals, Fano factor analysis), estimation (MLE, MAP), signal detection theory (d-prime, ROC analysis, psychometric curve fitting), information theory, discrete classification, continuous decoding (PVA, OLE), and white-noise analysis. Each topic covered will be linked back to the central ideas from undergraduate probability, and each assignment will involve actual analysis of neural data, either real or simulated, using Matlab. This class is meant for upper-level undergrads or beginning graduate students, and is geared to the engineer who wants to learn the neurophysiologist's toolbox and the neurophysiologist who wants to learn new tools. Those looking for broader neuroscience application (eg, fMRI) or more focus on regression analysis are encouraged to take 18-699. Prerequisites: undergraduate probability (36-225/227, or its equivalent), some familiarity with linear algebra and Matlab programming

Chemical Engineering Courses

06-100 Introduction to Chemical Engineering

Fall and Spring: 12 units

We equip students with creative engineering problem-solving techniques and fundamental chemical engineering material balance skills. Lectures, laboratory experiments, and recitation sessions are designed to provide coordinated training and experience in data analysis, material property estimation for single- and multi-phase systems, basic process flowsheet, reactive and non-reactive mass balances, problem solving strategies and tools, and team dynamics. The course is targeted for CIT First Year students. Corequisites: 21-120 and 09-105

06-200 Sophomore Research Project

Fall and Spring

Research projects under the direction of the Chemical Engineering faculty. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the faculty supervisor. The agreement should then be summarized in a one-page project description for review by the faculty advisor of the student. A final written report or an oral presentation of the results is required.

06-221 Thermodynamics

Fall: 9 units

This course introduces students to the process thermodynamics of single component systems. Topics include equilibrium and thermodynamic state variables; heat and work; conservation of energy and the first law of thermodynamics; entropy balances and the second law of thermodynamics; reversibility; free energies; interconversion of heat and work via engines, refrigeration and power cycles; absolute temperature and the third law of thermodynamics; equations of state; principle of corresponding states; thermodynamic property relationships; changes of state; phase equilibrium and stability in single component systems; vapor pressure and phase transition.

Prerequisites: 06-100 and 33-106

06-222 Sophomore Chemical Engineering Seminar

Fall: 1 unit

This course provides an overview of the chemical engineering profession. It discusses the rationale for the curriculum, career paths, resume writing, written communication skills, and ethics, and also involves a project on the use and manufacture of chemicals.

06-261 Fluid Mechanics

Spring: 9 units

The principles of fluid mechanics as applied to engineering, including unit operations, are discussed; examples include flow in conduits, process equipment, and commercial pipes, flow around submerged objects, and flow measurement. Microscopic mass and momentum balances are described, including the continuity and Navier-Stokes equations, and modern solution techniques will be explored. Microscopic flow structures will be determined for flow visualization. Boundary layer theory, turbulence, and non-Newtonian fluids are also discussed. A case-study project based on new technological advancements is also required.

Prerequisites: 06-100 and 21-259

Corequisite: 06-262

06-262 Mathematical Methods of Chemical Engineering

Spring: 12 units

Mathematical techniques are presented as tools for modeling and solving engineering problems. Modeling of steady-state mass and energy balance problems using linear and matrix algebra, including Gaussian elimination, decomposition, and iterative techniques. Modeling of unsteady-state engineering problems using linear and nonlinear differential equations. Analytical techniques, including Laplace transforms, and numerical techniques for the solution of first- and higher-order differential equations and systems of differential equations arising in engineering models. Finally, the modeling of processes affected by chance and subject to experimental error; statistical and regression techniques within the context of experimental design and analysis of experimental data.

Prerequisites: 06-100 and 06-221 and 21-122

06-300 Junior Research Project

Fall and Spring

Research projects under the direction of the Chemical Engineering faculty. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the faculty supervisor. The agreement should then be summarized in a one-page project description for review by the faculty advisor of the student. A final written report or an oral presentation of the results is required.

06-321 Chemical Engineering Thermodynamics

Fall: 9 units

The objective of this course is to cover principles and solution techniques for phase and chemical equilibria in multicomponent systems. Topics include thermodynamic properties of ideal and non-ideal mixtures; criteria for equilibrium; chemical potential, fugacity and activity coefficients; flash calculations; Gibbs energy minimization; thermodynamics of chemical reactions including equilibrium conversions.

Prerequisite: 06-221

06-322 Junior Chemical Engineering Seminar

Fall: 2 units

This course discusses career choices for chemical engineers, professional practice, including alternate career paths, global industry, and graduate studies. It also emphasizes writing, interview skills, and oral presentations. Safety, environmental and ethical issues are illustrated in projects and via invited lectures.

06-323 Heat and Mass Transfer

Fall: 9 units

This course presents the fundamentals of heat and mass transfer, including steady-state and transient heat conduction and molecular diffusion, convection of heat and mass, and thermal radiation, with application to heat and mass transfer processes. Development of dimensionless quantities for engineering analysis is emphasized.

Prerequisites: 06-261 and (06-262 or 21-260)

06-361 Unit Operations of Chemical Engineering

Spring: 9 units

This course comprises many of the standard operations in chemical plants such as gas absorption, heat exchange, distillation and extraction. The design and operation of these devices is emphasized. A project dealing with a novel unit operation is also investigated.

Prerequisites: 06-321 and 06-323

06-363 Transport Process Laboratory

Spring: 9 units

Develop skills for proposing, designing, planning, implementing, interpreting, and communicating the results of experiments in fluid flow and heat and mass transfer. Oral and written reports are required.

Prerequisites: 06-261 and 06-323

Course Website: <http://tlab12.cheme.cmu.edu/>**06-364 Chemical Reaction Engineering**

Spring: 9 units

Fundamental concepts in the kinetic modeling of chemical reactions, the treatment and analysis of rate data. Multiple reactions and reaction mechanisms. Analysis and design of ideal and non-ideal reactor systems. Energy effects and mass transfer in reactor systems. Introductory principles in heterogeneous catalysis.

Prerequisites: 06-323 and 09-347 and 06-321

06-365 Water Technology Innovation and Policy

Spring: 9 units

Innovation in water technologies is necessary to confront profound water resource challenges facing countries around the world. Students successfully completing this course will be able to discuss the factors and conditions that drive innovation in the water sector. Students will begin by describing and classifying the historical drivers for innovation in water treatment, including technical, economic, and regulatory drivers. After an introduction to the fundamental principles of water treatment technologies, students will identify present day technology shortcomings and distill these into discrete design objectives. Students will then formulate and answer quantitative and qualitative questions that respond to these design objectives by leveraging their knowledge of engineering fundamentals, regulatory tools, and pricing policies. Comparing their own solutions with those proposed in the peer-reviewed academic literature in engineering and the social sciences, students will evaluate the technical feasibility, usability, and social desirability of proposed water innovations in developed and developing countries and summarize their findings in policy briefs.

Prerequisites: 06-100 or 12-100 or 19-101 or 19-201

Corequisites: 27-216 or 24-322 or 06-323

06-400 Senior Research Project

Fall and Spring

Research projects under the direction of the Chemical Engineering faculty. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the faculty supervisor. The agreement should then be summarized in a one-page project description for review by the faculty advisor of the student. A final written report or an oral presentation of the results is required.

06-421 Chemical Process Systems Design

Fall: 12 units

Screening of processing alternatives. Computational strategies for preliminary material and energy balances in large chemical processes. Preliminary sizing of process equipment. Cost estimation, economics, and evaluation for chemical plants. Strategies for synthesizing energy networks and separation sequences. Preliminary design of a large industrial project.

Prerequisites: 06-321 and 06-361 and 06-364

06-423 Unit Operations Laboratory

Fall: 9 units

Open-ended laboratory projects illustrate the principles of unit operations in Chemical Engineering. In this course students select, with course staff review, current societal problems to which chemical engineering subject knowledge can be applied. Students work in teams to design and implement an experimental plan to evaluate proposed solutions. Teams must work together to identify constraints and relationships between the unit operations they work on. Students must document implementation feasibility (cost, scheduling, analytic capability, etc.) and clearly identify the criteria and methods for assessing experimental results. Oral and written reports are required.

Prerequisites: 06-361 and 06-364

06-426 Experimental Colloid Surface Science

Fall: 9 units

Laboratory exercises will deal with preparation and stabilization of colloids, flocculation, micellar aggregates, surface tension, contact angle, spreading and adsorption. Basic concepts will be related to practical problems of wetting, lubrication, foaming, adhesion, coatings and corrosion.

Prerequisites: 06-607 and 09-221

06-462 Optimization Modeling and Algorithms

Spring: 6 units

Formulation and solution of mathematical optimization problems with and without constraints. Objective functions are based on economics or functional specifications. Both discrete and continuous variables are considered.

Prerequisite: 06-421

06-463 Chemical Product Design

Spring: 6 units

Computer-aided design of a chemical product. Course involves design of molecular structure, microstructure, or devices/processes that effect chemical change. This is a project-based course, for which an extensive report must be submitted.

Prerequisite: 06-421

Corequisite: 06-462

06-464 Chemical Engineering Process Control

Spring: 9 units

This course presents basic concepts of process dynamics and feedback control. Included are selection of measurements and manipulated variables, definition of transfer functions, creation of block diagrams and closed loop configurations. The course also covers concepts of open loop and closed loop stability, and tuning of PID controllers.

Prerequisite: 06-262

06-466 Experimental Polymer Science

Spring: 9 units

Macromolecular behavior in bulk and in solution will be explored in experiments on tensile strength, elasticity, swelling of networks, solution viscosity, melt flow, and polymerization reactions. Particular reference will be made to aspects affecting production and fabrication of polymeric materials.

Prerequisites: 09-221 and (06-609 or 09-509)

06-606 Computational Methods for Large Scale Process Design & Analysis

Spring: 9 units

This course deals with the underlying computer-aided design techniques for steady-state and dynamic simulation, numerical solution and decomposition strategies for large systems of sparse nonlinear algebraic equations, stiff ordinary differential equations, strategies for mixed algebraic/differential systems and computer architectures for flowsheeting systems.

Prerequisites: 06-262 and 06-361

06-607 Physical Chemistry of Colloids and Surfaces

All Semesters: 9 units

Thermodynamics of surfaces; adsorption at gas, liquid, and solid interfaces; capillarity; wetting, spreading, lubrication and adhesion; properties of monolayers and thin films; preparation and characterization of colloids; colloidal stability, flocculation kinetics, micelles, electrokinetic phenomena and emulsions.

Prerequisites: 06-221 and 09-347

06-608 Safety Issues in Science and Engineering Practice

Fall: 3 units

Exposes the students to personal safety issues encountered in normal science and engineering practice. Topics covered include mechanical, electrical, chemical, radiation, and biological hazards, to provide an awareness of these hazards and appropriate action to be taken in the event of an accident.

06-609 Physical Chemistry of Macromolecules

Fall: 9 units

This course develops fundamental principles of polymer science. Emphasis is placed on physico-chemical concepts associated with the macromolecular nature of polymeric materials. Engineering aspects of the physical, mechanical and chemical properties of these materials are discussed in relation to molecular structure. Topics include an introduction to polymer science and a general discussion of commercially important polymers; molecular weight; condensation and addition synthesis mechanisms with emphasis on molecular weight distribution; solution thermodynamics and molecular conformation; rubber elasticity; and the rheological and mechanical properties of polymeric systems. Students not having the prerequisite listed may seek permission of the instructor.

Prerequisite: 09-347

06-610 Rheology and Structure of Complex Fluids

Fall: 9 units

This course will cover the basic concepts of rheology and mechanical behavior of fluid systems. Both the experimental and theoretical aspects of rheology will be discussed. The basic forces influencing complex fluid rheology and rheology will be outlined and discussed; including excluded volume, van der Waals, electrostatic and other interactions. Methods of characterizing structure will be covered including scattering techniques, optical polarimetry and microscopy. Examples will focus on several types of complex fluids including polymer solutions and melts, gelling systems, suspensions and self-assembling fluids.

Prerequisites: 06-609 or 09-509

06-619 Semiconductor Processing Technology

Spring: 9 units

This is an introductory course to the physical and chemical concepts involved in integrated circuit processing. The material focuses on basic principles in chemical reaction engineering and how they can be applied to integrated circuit process engineering. Students not having the prerequisites listed may seek permission of the instructor.

Prerequisites: 06-364 and 09-347

06-620 Global Atmospheric Chemistry: Fundamentals and Data Analysis Methods

Spring: 9 units

This course will explore global atmospheric chemistry through a series of case studies: Stratospheric Ozone, Global Methane and OH, and Urban and Regional Ozone. Each case will begin with a description of the chemistry and atmospheric physics fundamental to the particular problem. Students will formulate testable mathematical models incorporating that chemistry and physics, turning then to existing atmospheric data sets to test current understanding. The emphasis of this course is to develop an understanding of how to pose a testable hypotheses in a complex chemical environment such as the atmosphere, validate or refute those hypotheses, and then by extension predict how the system will respond to perturbations. A particular objective is to explore how to extend this methodology from the stratosphere and background troposphere (the first two cases), where it has been applied with success, to the much more complicated problem of urban and regional air quality. Students not having the prerequisites listed may seek permission of the instructor.

Prerequisites: 06-262 and 09-105

06-621 Biotechnology and Environmental Processes

Fall: 9 units

First half of the course: microbial physiology and metabolism, fermentations and respiration, metabolic regulation, bioconversions, recombinant DNA methodology and gene cloning. Second half: separation and purification, kinetics and design of biological reactors, mass transfer limitations within cell suspensions, and control of fermentation processes. Lectures will cover aspects of accuracy and resolution, relative merits and limitations, selection criteria, and typical practical applications for these devices. Several laboratory demonstrations will be provided. Each student will be expected to submit a project report on a topic assigned in the beginning of the course.

Prerequisites: 03-231 or 03-232

06-622 Bioprocess Design

Fall and Spring: 9 units

This course is designed to link concepts of cell culture, bioseparations, formulation and delivery together for the commercial production and use of biologically-based pharmaceuticals; products considered include proteins, nucleic acids, and fermentation-derived fine chemicals. Associated regulatory issues and biotech industry case studies are also included. A fair knowledge of cell culture and fermentation operations is assumed.

Prerequisites: 06-621 or 42-621

06-630 Atmospheric Chemistry, Air Pollution and Global Change

Fall and Spring: 12 units

Principles necessary to understand the atmospheric behavior of air pollutants in urban, regional, and global scales are the subjects of this course. Key topics include atmospheric gas-, aqueous-, and aerosol-phase chemistry; removal processes and residence times; aerosol physics; pollutant effects on visibility and the energy balance of the planet; mathematical modeling of air pollution. The student finishing the course will understand the fundamentals of atmospheric chemistry and physics and their relationship to urban, regional, and global pollution problems. Students not having the prerequisites listed may seek permission of the instructor.

Prerequisites: 06-262 and 09-105

06-640 Principles and Applications of Molecular Simulation

Fall and Spring: 9 units

This course will introduce modern concepts and methods for simulating physical and thermodynamics properties of materials from atomic-scales, with special emphasis on the gas and liquid states. Strengths and limitations of molecular simulation methods will be discussed. Topics will include basic statistical mechanics, interatomic potentials, Molecular Dynamics methods, Monte Carlo methods, computation of phase coexistence curves, and Brownian Dynamics.

Prerequisites: 06-262 and 06-321

06-679 Introduction to Meteorology

Fall: 12 units

to be determined by the department

06-708 Advanced Process Dynamics and Control

Spring: 12 units

Modeling and simulation of dynamic behavior of chemical processes. Theoretical and practical aspects of development of optimal and various regulatory control schemes for start-up and continuous process operation. Application of filtering techniques for noisy or estimated data. Process automation.

06-714 Surfaces and Adsorption

Fall: 12 units

A survey of solid surfaces and gas-solid interactions. Topics include the structure and electronic properties of metal surfaces, the kinetics and thermodynamics of adsorption and desorption processes, and concepts in heterogeneous catalysis. The course emphasizes the application of recent experimental techniques in studying these problems.

06-720 Advanced Process Systems Engineering

Spring: 12 units

A general background on problems, methods, and tools for solving analysis and synthesis problems in process engineering. Formulation and numerical solutions of steady-state and dynamic simulation and optimization problems will be discussed. Insights and solution methods are also covered, based on both heuristics and mixed-integer programming techniques for the synthesis of heat exchanger networks, separation processes, and total process systems.

Chemistry Courses

09-101 Introduction to Experimental Chemistry

Summer: 3 units

This is a seven week chemistry laboratory course that is designed to introduce students to some basic laboratory skills, techniques, and equipment commonly used in experimental chemical investigations. The experiments will apply concepts in organic synthesis, quantitative analysis using visible spectrophotometry, kinetics, acid-base chemistry, thermochemistry, transition metal chemistry, chromatography, and protein biochemistry. 1 hr. lec., 3 hrs. lab.

09-102 Special Topics

Intermittent: 3 units

A selection of mini-courses offered to introduce first-year students to special topics in modern chemistry. The courses meet for half a semester and may include some hands-on laboratory and computer experiences. Topics vary, but have included: Forensic Chemistry in the Criminal Justice System, Macromolecules for Nanotechnology, Popularization of Science Through Books, Plays and Film, Kaboom and Other Approaches to Teaching Science, Dating Using Radioactivity and Computer Molecular Modeling. Enrollment limited to first-year MCS and SHS students.

09-103 Atoms, Molecules and Chemical Change

Fall: 9 units

This is a one-semester introductory college level course designed for non-science and engineering majors who have had a high school course in chemistry. Students with primary or additional majors in MCS, CIT or SCS will not be allowed to enroll. Chemistry topics will be introduced on an as needed basis in the contexts of air pollution, the ozone layer, global warming, acid rain, safe drinking water, alternative energy sources, plastics, and drug design. Students will apply concepts in topics such as the classification of matter, the relationship between matter and energy, atomic theory and the Periodic Table, chemical bonding, molecular shapes, molecular polarity, interparticle forces, chemical reactions, stoichiometry, properties of aqueous solutions, acid-base chemistry, redox chemistry, and organic chemistry. Students will gain an understanding of how chemistry impacts major environmental, social, political, and economic issues that we encounter daily. They will also learn to apply chemical concepts to new situations or contexts. Students with credit for 09-105 or more advanced chemistry courses will not be allowed to enroll in this course. 3 hrs. lec., 1 hr. rec.

09-104 Fundamental Aspects of Organic Chemistry and Biochemistry

Intermittent: 9 units

This course, which includes demonstrations and "hands-on" activities, is designed to engage non-majors in the fascination of chemistry. It is not essential that a student has completed 09-103 in order to take this course. The lecture part of this course will include wide ranging science topics designed to put the world of chemistry in perspective. After achieving a competency in fundamentals we proceed to systematically survey the important topics of synthesis, structure and mechanism in organic chemistry. With these insights we finally confront the important biological molecules including DNA. 3 hrs lec., 1 hr rec.

09-105 Introduction to Modern Chemistry I

Fall and Spring: 10 units

This course begins with a very brief survey of some fundamental principles of chemistry and a presentation of chemically interesting applications and sophisticated problems. These will form the basis for introducing the relationships between the structure of molecules and their chemical properties and behavior. The subject matter will include principles of atomic structure, chemical bonding, intermolecular interactions and molecular structures of organic and inorganic compounds including some transition metal complexes. Relevant examples will be drawn from such areas as environmental, materials, and biological chemistry. 3 hrs. lec, 2 hrs. rec.

09-106 Modern Chemistry II

Fall and Spring: 10 units

This course provides an overview of thermodynamics, kinetics and chemical equilibrium. Topics include the flow of energy in chemical systems; the spontaneity of chemical processes, i.e. entropy and free energy; the mechanisms and rates of chemical reactions; and the use of chemical equilibrium to reason about acid-base chemistry, solubility and electrochemistry. Applications include the energy economy, biological systems and environmental chemistry. 3 hrs. lec., 2 hrs. rec.

Prerequisites: 09-105 or 09-107

09-107 Honors Chemistry: Fundamentals, Concepts and Applications

Fall: 10 units

Honors Chemistry is an introductory course that teaches the foundations of Modern Chemistry and applies them to current scientific issues, such as Green Chemistry, Biotechnology and Materials Science. Topics include modern theories of bonding, organization of atoms, molecular interactions, biochemistry and transition metal chemistry. Enrollment is limited to first-year students, with priority given to those in MCS. 3 hrs. lec., 2 hrs. rec.

09-109 Kitchen Chemistry Sessions

Intermittent: 3 units

Ever wanted to boil water in ice? Cook an egg so the yolk is set but the white still runny? Lick a lemon or drink vinegar but have it taste sweet? Make "caviar" from fruit juice and noodles from yogurt? Explore the science of molecular gastronomy through the lectures and demonstrations that reveal the chemistry and biochemistry of food ingredients and their preparation. Then use a kitchen as your "laboratory" to test hypotheses and delve into molecular cooking - you may just get to eat your lab results. For this course high school background in chemistry would help but nothing more advanced is required. Concepts will be discussed on a need to know basis. Students with stronger chemistry backgrounds should enroll in 09-209. 3 hrs. lec. and lab

09-122 Molecular Tools for Biological and Chemical Studies

Spring: 6 units

The increased fluorescence of certain molecules, also known as dyes, can signal their binding to a specific biological target such as DNA. This phenomenon finds important application in the biological and medicinal field where dyes are used as molecular tools. For example, fluorescent dyes can be used to detect the expression of a gene; survival of cells; site of accumulation of a metabolite and many of them are used in diagnostics. This course is aimed at offering a hands-on laboratory experience in the interface of chemistry and biology, so called bioorganic chemistry. The student's project will be to prepare a dye, thiazole orange, that will show increased fluorescence upon binding DNA or a protein, thus, signaling the binding event. A dye designed to prevent DNA binding will be tested alongside to highlight how molecular design works. Molecular size and geometry are important elements in the design of molecules that specifically bind biological targets; 3D molecular modeling software (freeware) and hand-held models will be used to analyze how these factors play a role in target-dye interaction.

09-201 Undergraduate Seminar I

Fall: 1 unit

Issues and topics of importance to beginning chemistry majors are discussed in this course. It provides a general introduction to the facilities, faculty and programs of the Department of Chemistry and introduces students to career and research opportunities in the field of chemistry. Enrollment limited to students majoring in chemistry. 1 hr.

09-202 Undergraduate Seminar II: Safety and Environmental Issues for Chemists

Spring: 1 unit

Issues and topics focused on laboratory safety are discussed in this class. The topics are selected to supplement information covered in 09-221, Laboratory I. This course is intended to provide the necessary safety training for students wishing to undertake undergraduate research projects in the laboratory and is taught in collaboration with the Office of Environmental Health and Safety. Enrollment is limited to chemistry majors. 1 hr.

09-204 Professional Communication Skills in Chemistry

Spring: 3 units

This required course for chemistry majors promotes development of written and oral communication skills in various formats within the discipline. Students are expected to develop these skills by becoming more familiar with the style and format of the chemical literature, current topics in chemistry, and research projects in the Department. Other learning outcomes include developing critical reading skills, providing effective feedback to peers' written and oral communication, demonstrating the ability to revise written work, and using chemical structure drawing software. 1 hr. lec.
Prerequisite: 09-221

09-207 Techniques in Quantitative Analysis

Fall: 9 units

09-207 is the first of two chemistry lab courses required for the BS and BA degrees in biological sciences and the intercollege major in biological sciences and psychology. It is also suitable for fulfilling the requirement for two general chemistry labs for admission to programs in the health professions. The experimental work emphasizes the techniques of quantitative chemical analysis. Included are projects dealing with a variety of instrumental and wet chemical techniques. A mixture of individual and partner experiments concluding with one team experiment is conducted during the semester. In addition to laboratory techniques, safety, and written communication skills are emphasized.
Prerequisite: 09-106

09-208 Techniques for Organic Synthesis and Analysis

Spring: 9 units

09-208 is the second of two chemistry laboratory courses required for the BS in biological sciences and the intercollege major in psychology and biological sciences. It is also suitable for fulfilling the requirement for the laboratory experience for application to programs in the health professions. The course emphasizes experimental work in separations, synthesis, and analysis of organic compounds, including chromatography and spectroscopy. Written communication skills will be developed by means of laboratory reports and essays.
Prerequisites: (09-219 or 09-217) and (09-221 or 09-207)
Corequisites: 09-220 and 09-218

09-209 Kitchen Chemistry Sessions

Intermittent: 3 units

Ever wanted to boil water in ice? Cook an egg so the yolk is set but the white still runny? Lick a lemon or drink vinegar but have it taste sweet? Make "caviar" from fruit juice and noodles from yogurt? Explore the science of molecular gastronomy through the lectures and demonstrations that reveal the chemistry and biochemistry of food ingredients and their preparation. Then use a kitchen as your "laboratory" to test hypotheses and delve into molecular cooking - you may just get to eat your lab results. Students enrolling in this course are assumed to have a college level background in chemistry including introductory organic chemistry. Students without a solid chemistry background should take the lower level 09-109. 3 hrs. lec. and lab
Prerequisites: 09-217 or 09-219

09-214 Physical Chemistry

Spring: 9 units

This is a one-semester course intended primarily for students majoring in Biological Sciences, students pursuing a B.A. degree program in Chemistry, and students in the B.S.A. program with a concentration in chemistry. The course focuses on thermodynamics, transport and reaction rates and their application to chemical and biological systems. Emphasis is given to attaining a good fundamental understanding of entropy and free energy. This is more a concepts than skills building course. Topics include applications of thermodynamics to chemical and biochemical equilibria, electrochemistry, solutions, and chemical kinetics. 3 hrs. lec. Prerequisites: 09106 and 21122 and (33111 or 33106)
Prerequisites: 09-106 and (21-124 or 21-122) and (33-111 or 33-106)

09-217 Organic Chemistry I

Fall: 9 units

This course presents an overview of structure and bonding as it pertains to organic molecules. Selected topics include: introduction to functional group chemistry, stereochemistry, conformational analysis, reaction mechanisms and use of retrosynthetic analysis in the development of multistep syntheses. Methods for structure determination of organic compounds by modern spectroscopic techniques are introduced. 3 hrs. lec., 1 hr. rec.
Prerequisites: 09-105 or 09-107

09-218 Organic Chemistry II

Spring: 9 units

This course further develops many of the concepts introduced in Organic Chemistry I, 09-217. Emphasis is placed on the utilization of reaction mechanisms for understanding the outcome of chemical transformations, and the employment of a wide variety of functional groups and reaction types in the synthesis of organic molecules. Also included in the course will be special topics selected from the following; polymers and advanced materials, biomolecules such as carbohydrates, proteins and nucleic acids, and drug design. 3 hrs. lec., 1 hr. rec.
Prerequisites: 09-217 or 09-219

09-219 Modern Organic Chemistry

Fall: 10 units

Traditional introductory organic chemistry courses present structure, reactivity, mechanisms and synthesis of organic compounds. Students taking 09-219 will be exposed to the same topics, but presented in greater depth and broader context, with applications to allied fields such as (1) polymer and materials science, (2) environmental science and (3) biological sciences and medicine. This will be accomplished through an extra 50 minute lecture period, where more advanced topics and applications will be discussed. Topics will include computational chemistry, green chemistry, chiral separations, photochemistry, reaction kinetics, controlled radical polymerizations and petroleum cracking. Students who complete 09-219 will have a strong foundation in organic chemistry as well as a sophisticated understanding of how organic chemistry is currently practiced. 4 hrs. lec., 1 hr. rec.
Prerequisites: 09-105 or 09-107

09-220 Modern Organic Chemistry II

Spring: 10 units

This course builds on 09-219 by introducing students to additional functional groups, chemical reaction mechanisms and synthetic strategies commonly used in the practice of organic chemistry. Advanced topics to be presented during the extra lecture will include multidimensional NMR spectroscopy, enantioselective synthesis, ionic polymerization, bioorganic and medicinal chemistry, natural products chemistry and toxicology. Students who complete 09-220 will have a strong foundation in synthetic, mechanistic and structural organic chemistry and will understand how this applies to human health and the environment. 4 hrs. lec, 1 hr. rec.
Prerequisite: 09-219

09-221 Laboratory I: Introduction to Chemical Analysis

Fall and Spring: 12 units

This course is the first in a sequence of four laboratory courses on experimental aspects of chemistry required for the B.S. degree in chemistry. The experimental work emphasizes the techniques of quantitative chemical analysis. Included are projects dealing with a variety of instrumental and wet chemical techniques. The course is project-oriented with the experiments becoming more complex, requiring greater student input into the experimental design as the semester progresses. A mixture of individual and team experiments are conducted during the semester. In addition to techniques, safety, written and oral communication skills, and effective teamwork are emphasized. 2 hrs. lec., 6 hrs. lab.
Prerequisite: 09-106

09-222 Laboratory II: Organic Synthesis and Analysis

Fall and Spring: 12 units

In this second course in the laboratory sequence, students acquire laboratory skills relevant to synthesis and purification of organic compounds, as well as the practical use of chromatography and spectroscopy. Students will also further develop technical writing skills through preparation of lab reports. 2 hrs. lec., 6 hrs. lab.
Prerequisites: (09-219 or 09-217) and 09-221
Corequisites: 09-220 or 09-218

09-231 Mathematical Methods for Chemists

Fall: 9 units

This course covers mathematical techniques that are important in the chemical sciences. The techniques will be covered in the context of chemical phenomena, and combine topics from 3-dimensional calculus, differential equations, linear algebra and statistics. This course does not count towards the minor in chemistry. 3 hrs. lec.

Prerequisites: 09-106 and (21-124 or 21-122)

09-301 Undergraduate Seminar III

Fall: 1 unit

Students attend seminars on current topics in chemistry. Students are sent a menu of choices for each week of the semester and may select topics of interest. Enrollment is restricted to students majoring in chemistry. 1 hr.

09-302 Undergraduate Seminar IV

Spring: 1 unit

Students attend seminars presented by senior chemistry majors. Students provide peer evaluations of the seminars and through the process students become familiar with special topics in chemistry. The course establishes what should be included in a good seminar. This seminar course is one of 6 required for the chemistry major. If a schedule conflict exists, students may, with permission of the instructor, attend other chemistry seminars or make other arrangements to fulfill the requirement. 1 hr.

09-321 Laboratory III: Molecular Design and Synthesis

Fall: 12 units

In this third course in the laboratory sequence, students will learn a variety of more advanced techniques for organic synthesis and characterization, and will gain experience with developing and designing synthetic procedures. Student writing skills are further reinforced through preparation of detailed lab reports. 2 hrs. lec., 6 hrs. lab.

Prerequisites: (09-218 or 09-220) and 09-222

09-322 Laboratory IV: Molecular Spectroscopy and Dynamics

Spring: 12 units

This laboratory course is devoted to physical chemistry experiments, which involve the use of modern spectroscopic instrumentation to probe the optical and magnetic properties of molecules. The experiments include the use of high-resolution infrared, laser Raman, NMR, EPR, fluorescence, and UV-visible spectroscopies. Additional experiments demonstrate methods for measuring enzyme-catalyzed reaction rate constants, and the use of scanning probe microscopy for imaging and characterization of biological macromolecules. Throughout the course the students will learn how to use computer algebra packages for rigorous data analysis and modeling and will develop the skills in basic electronics, and vacuum techniques. 2 hrs. lec., 6 hrs. lab.

Prerequisites: 09-344 and 09-331 and 09-221

Corequisite: 09-345

09-323 Bioorganic Chemistry Laboratory

12 units

Bioorganic chemistry is concerned with the action of synthesized compounds on biological systems. In order to maximize the likelihood of identifying a biologically active compound, synthetic libraries are often employed, requiring extensive familiarity with simple, efficient chemical coupling steps and protecting group chemistry. In this inquiry based laboratory course, using a process that mimics the current practice in drug discovery by pharmaceutical companies, students will rationally design a compound library in hopes of finding a compound active against a selected biological target, search for active compounds in the library, and then quantitatively characterize any identified compounds for activity. Working in small groups, students will develop proposals for and execute the target assay selected, the library synthesis, and the screening approach. Students will write reports summarizing the results in each phase of the course.

Throughout the course, students will be introduced to concepts relevant to industrial scientific research, including regulatory compliance, quality control and assurance, and intellectual property.

Prerequisites: (09-220 or 09-218) and 09-222

09-331 Modern Analytical Instrumentation

Fall: 9 units

This course will cover all aspects of analytical instrumentation and its application to problems in materials, environmental, and biological chemistry. Topics covered will include mass spectrometry, optical spectroscopies and NMR. In addition, the course will emphasize how to select an analytical method appropriate to the problem at hand, how to optimize the signal to noise obtained by a measurement, and the quantitative analysis of experimental data. Some basic electronics will be covered as well. 3 hrs. lec.

Prerequisites: 09-221 and 09-222

09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry

Fall: 9 units

The measurement and theoretical description of the properties of atoms and molecules are presented. The elementary principles of quantum chemistry are developed. The many types of spectroscopy used to study atoms and molecules are described. Methods of atomic structure determination are discussed. The structure and properties of solids are also presented. The basic results of statistical chemistry are outlined and a brief connection to thermodynamics is made. 3 hrs. lec., 1 hr. rec.

Prerequisites: (09-107 or 09-105) and (33-111 or 33-106)

Corequisite: 09-231

09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry

Spring: 9 units

The measurement and theoretical descriptions of the equilibrium properties of chemical systems are presented. Chemical thermodynamics is introduced at the upper division level. The phases of matter are discussed. The quantitative treatment of mixtures is developed. The detailed description of chemical equilibrium is elaborated. The measurement and theoretical description of the nonequilibrium properties of chemical systems are presented. Elementary transport properties are introduced. The principles of classical chemical kinetics are developed in great detail. 3 hrs. lec., 1 hr. rec.

Prerequisites: 09-106 and (21-259 or 09-231)

09-347 Advanced Physical Chemistry

Fall: 12 units

09-347 Advanced Physical Chemistry Fall: 12 units A course of study designed to provide the microscopic basis of concepts encountered in the field of chemical engineering. The properties of macroscopic materials are calculated in terms of the microscopic properties of atoms and molecules. Both classical and quantum approaches are employed. The thermodynamic properties are developed in terms of the chemical potentials of the constituent particles. The transport properties are calculated using molecular dynamics and Brownian dynamics. Classical chemical kinetics is fully developed and applied to complex reactions. Rate constants are calculated for simple reactions in gases and solutions. The course enrollment is limited to chemical engineering majors. 4 hrs. lec.

Prerequisites: (06-151 or 06-221) and (06-262 or 06-155) and 09-106 and (33-112 or 33-107)

09-348 Inorganic Chemistry

Spring: 10 units

The focus of this class is understanding the properties of the elements and of the inorganic compounds. The electronic structure of elements is discussed as the basis for the element's organization in the Periodic Table and for their properties. The systematic chemistry of main group elements and of transition metals is presented. The number of inorganic compounds is extremely large and their properties are extremely diverse. Therefore in this course, the presentation of physical and chemical properties of inorganic compounds is based upon the observation of the trends in the respective properties and the relation between these trends and the place of the elements in the Periodic Table. 3 hrs. lec., 1 hr. rec.

Prerequisites: (09-105 or 09-107) and 21-120

09-401 Undergraduate Seminar V

Fall: 1 unit

Students attend seminars on current topics in chemistry. Students are sent a menu of choices for each week of the semester and may select topics of interest. Enrollment is restricted to students majoring in chemistry. 1 hr.

09-402 Undergraduate Seminar VI

Fall and Spring: 3 units

Students enrolled in this course present a 20 - 30 minute oral report on a current topic in chemistry. This may be from the student's research work or a special chemistry topic of general interest. Presentations or papers prepared for other courses are not acceptable for this purpose. Thoroughness in the use of the chemical literature is emphasized. The use of presentation aids such as PowerPoint is required. Other students in the class submit written evaluations of the presentation. Talks are recorded for viewing by the student and instructor as a means of providing individualized feedback about presentation skills. A seminar presentation is required of all chemistry majors. No exceptions possible. Enrollment is limited to students majoring in chemistry. 1 hr.

09-435 Independent Study Chemistry

All Semesters

The course allows students to earn academic credit for concentrated study in a topic area developed in conjunction with and monitored by a faculty member in the Department of Chemistry. These topics are distinct from projects that would rise to the level of undergraduate research either because they are in unrelated areas distinct from the faculty member's research interests or may constitute the investigation and compilation of existing information from a variety of resources and may not be expected to result in the generation of new information as is a reasonable expected outcome in undergraduate research (likely is not publishable).

09-445 Undergraduate Research

Fall and Spring

Properly qualified students may undertake research projects under the direction of members of the faculty, normally 6 to 12 hrs/week. A written, detailed report describing the project and results is required. Course may be taken only with the consent of a faculty research advisor in chemistry or on occasion in another department provided that the project is chemical in nature and with permission of the Director of Undergraduate Studies. The number of units taken generally corresponds to the actual number of hours the student actually spends in the lab doing research during the week. Maximum number of units taken per semester is 18.

09-455 Honors Thesis

Fall and Spring

Students enrolled in the departmental honors program (B.S. with Departmental Honors or combined 4-year B.S./M.S. degree) are required to enroll in this course to complete the honors degree requirements. A thesis written in an acceptable style describing an original research project, and a successful oral defense of the thesis topic before a Thesis Committee are required. Limited to students accepted into the honors program. (B.S. Honors candidates normally enroll for 6 units; B.S./M.S. candidates enroll for 15 units.)

09-502 Organic Chemistry of Polymers

Spring: 9 units

A study of the synthesis and reactions of high polymers. Emphasis is on practical polymer preparation and on the fundamental kinetics and mechanisms of polymerization reactions. Topics include: relationship of synthesis and structure, step-growth polymerization, chain-growth polymerization via radical, ionic and coordination intermediates, copolymerization, discussions of specialty polymers and reactions of polymers. 09-509, Physical Chemistry of Macromolecules, is excellent preparation for this course but is not required. 3-6 hrs. lec. (Graduate Course: 12 units, 09-741)

Prerequisites: 09-218 or 09-220

09-507 Nanoparticles

Intermittent: 9 units

This course discusses the chemistry, physics, and biology aspects of several major types of nanoparticles, including metal, semiconductor, magnetic, carbon, and polymer nanostructures. For each type of nanoparticles, we select pedagogical examples (e.g. Au, Ag, CdSe, etc.) and introduce their synthetic methods, physical and chemical properties, self assembly, and various applications. Apart from the nanoparticle materials, other topics to be briefly covered include microscopy and spectroscopy techniques for nanoparticle characterization, and nanolithography techniques for fabricating nano-arrays. The course is primarily descriptive with a focus on understanding major concepts (such as plasmon, exciton, polaron, etc.). The lectures are power point presentation style with sufficient graphical materials to aid students to better understand the course materials. Overall, this course is intended to provide an introduction to the new frontiers of nanoscience and nanotechnology. Students will gain an understanding of the important concepts and research themes of nanoscience and nanotechnology, and develop their abilities to pursue highly disciplinary nanoscience research. The course should be of interest and accessible to advanced undergraduates and graduate students in fields of chemistry, materials science, and biology. 3 hrs. lec.

Prerequisites: (33-107 or 33-112) and 09-106

09-509 Physical Chemistry of Macromolecules

Fall: 9 units

This course develops fundamental principles of polymer science. Emphasis is placed on physio-chemical concepts associated with the macromolecular nature of polymeric materials. Engineering aspects of the physical, mechanical and chemical properties of these materials are discussed in relation to chain microstructure. Topics include an introduction to polymer science and a general discussion of commercially important polymers; molecular weight; condensation and addition synthesis mechanisms with emphasis on molecular weight distribution; solution thermodynamics and molecular conformation; rubber elasticity; and the rheological and mechanical properties of polymeric systems. (This course is also listed as 06-609. Graduate Course: 12 units, 09-715) 3 hrs. lec.

Prerequisites: 09-345 or 09-347

09-510 Chemistry and Sustainability

Spring: 9 units

This course aims to educate students in the foundations of systematic leadership for building a sustainable world. Many sustainability challenges are associated with commercial chemicals and with operational modes of the chemical enterprise. For scientists, effectiveness in solving the technical challenges and redirecting cultural behavior is the defining substance of sustainability leadership. The course aims to challenge students to analyze and understand the root causes of unsustainability, especially in the technological dimension, to imagine a more sustainable world and to begin to define personal leadership missions. Students will be introduced to sustainability ethics as the foundation stone of transformative sustainability leadership, to the Collins ?Sustainability Compass? and ?Code of Sustainability Ethics? and to the Rob rt/Broman ?Framework for Strategic Sustainable Development (FSSD)? as powerful guiding tools. The Collins ?Bookcase of Green Science Challenges? organizes the technical content. It systematizes the major chemical sustainability challenges of our time: clean synthesis, renewable feed-stocks, safe energy, elemental pollutants, persistent molecular toxicants and endocrine disruptors. Focal areas will be the technical, toxicological and cultural histories of elemental and molecular pollutants and endocrine disruptor (ED) science?EDs represent the single greatest sustainability challenge of everyday chemicals. The graded substance will take the form of take-home work. Students will primarily read key books and articles and will summarize and personally evaluate the material in essay assignments. The course is intended for upper level undergraduates and graduates. There are no other prerequisites. The class is limited to 25 students. The 09-510 assignments are common to both undergraduate and graduate classes offerings. (Graduate course 12 units 09-710) 3 hrs. lec.

Prerequisites: 09-105 or 09-107

09-517 Organotransition Metal Chemistry

Intermittent: 9 units

The first half of this course focuses on the fundamentals of structure and bonding in organotransition metal complexes and how the results can be used to explain, and predict, chemical reactivity. The latter half of the course covers applications, and more specifically, homogeneous catalysts for industrial processes and organic synthesis. (Graduate Course: 12 units, 09-717)

Prerequisite: 09-348

09-518 Biorganic Chemistry: Nucleic Acids and Carbohydrates

Fall: 9 units

This course will introduce students to new developments in chemistry and biology, with emphasis on the synthesis, structural and functional aspects of nucleic acids and carbohydrates, and their applications in chemistry, biology and medicine. Later in the course, students will have the opportunity to explore cutting-edge research in this exciting new field that bridges chemistry with biology. Students will be required to keep abreast of the current literature. In addition to standard homework assignments and examinations, students will have the opportunity to work in teams to tackle contemporary problems at the forefront of chemistry and biology. The difference between the 09-518 (9-unit) and 09-718 (12-unit) is that the latter is a graduate level course. Students signed up for 09-718 will be required to turn in an original research proposal at the end of the course, in addition to all the other assignments. (Graduate Course: 12 units, 09-718) 3 hrs. lec.

Prerequisites: 03-121 and (09-218 or 09-220)

09-519 Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry

Spring: 9 units

This course will introduce students to new developments in chemistry and biology, with emphasis on the synthesis, structural and functional aspects of peptides, proteins and small molecules. Basic concepts of bioorganic chemistry will be presented in the context of the current literature and students will have the opportunity to learn about the experimental methods used in various research labs. An introduction to combinatorial chemistry in the context of drug design and drug discovery will also be presented. Students will be required to keep abreast of the current literature.

Homeworks and team projects will be assigned on a regular basis. The homework assignments will require data interpretation and experimental design; and team projects will give students the opportunity to work in teams to tackle contemporary problems at the interface of chemistry and biology. Students enrolled in the graduate level course (09-719) will be required to turn in an original research proposal at the end of the course, in addition to the homework assignments, midterm, and final exam that are required for the undergraduate course. (Graduate Course: 12 units 09-719) 3 hrs. lec.

Prerequisites: 03-121 and (09-218 or 09-220)

09-520 Global Atmospheric Chemistry: Fundamentals and Data Analysis Methods

Intermittent: 9 units

This course will explore global atmospheric chemistry through a series of case studies: Stratospheric Ozone, Global Methane and OH, and Urban and Regional Ozone. Each case will begin with a description of the chemistry and atmospheric physics fundamental to the particular problem. Students will formulate testable mathematical models incorporating that chemistry and physics, turning then to existing atmospheric data sets to test current understanding. The emphasis of this course is to develop an understanding of how to pose a testable hypotheses in a complex chemical environment such as the atmosphere, validate or refute those hypotheses, and then by extension predict how the system will respond to perturbations. A particular objective is to explore how to extend this methodology from the stratosphere and background troposphere (the first two cases), where it has been applied with success, to the much more complicated problem of urban and regional air quality. (This course is also listed as 06-620.)

Prerequisites: 09-231 or 21-260

Corequisites: 09-347 or 09-344

09-521 Bioinorganic Chemistry

Intermittent: 9 units

The course addresses the basis for the selection and regulation of metal atoms and ligand systems and their interactions with their corresponding protein environments. The chemistry of catalytic processes in metalloenzymes, and atom transfer and electron transport in metalloproteins will be reviewed. The array of physical methods required for study will be introduced, with application toward the determination of electronic and molecule structure and enzymatic mechanisms. (Graduate Course: 12 units, 09-721) 3 hrs. lec.

Prerequisites: 09-344 and 09-348

09-522 Oxidation and Inorganic Chemistry

Intermittent: 9 units

The roles of metal complexes in chemical and biochemical oxidations will be presented. Special attention is given to processes involving the activation of molecular oxygen and hydrogen peroxide by metal complexes and metalloenzymes from a mechanistic viewpoint. Much attention is devoted to kinetic methods of investigation of homogeneous reactions and mechanisms of oxidative catalysis. For this reason, a mini course on mechanisms of chemical reactions in solution is integrated. Redox properties and electronic structures of metal complexes will be reviewed. The relationships between electronic structures, catalytic properties, and oxidation reactivity of biologically relevant metal complexes will be provided. Mechanistic pathways of oxidation by peroxidases, cytochrome P-450, and other metalloenzymes will be described. (Graduate course: 09-722, 12-units) 3 hrs. lec.

Prerequisite: 09-348

09-524 Environmental Chemistry

Spring: 9 units

Environmental pollutants are common consequences of human activities. These chemicals have a wide range of deleterious effects on the environment and people. This course will introduce students to a range of major environmental pollutants, with a particular focus on persistent organic pollutants. We will use chemical principles including thermodynamics, kinetics, photochemistry, organic reaction mechanisms, and structure-activity relationships to understand the environmental fate of major classes of pollutants. The transport of chemicals through the environment and their partitioning between air, water, soil, and people will be described. The major environmental reaction pathways (oxidation, photolysis, hydrolysis, reduction, metabolism) of common pollutants will be explored. This will provide students with the necessary knowledge to predict the chemical fate of environmental pollutants, and improve their understanding of the environmental impacts of their everyday chemical use and exposure. Specific topics include water quality, photochemical smog, organic aerosols, atmospheric chemistry and global climate change, toxicity of pesticides, and heterogeneous and multiphase atmospheric chemistry. The 12-unit course is intended for graduate students that want to explore aspects of the course more deeply. This includes additional requirements including a final term paper and in-class presentation, and additional advanced questions on the homework assignments.

Prerequisites: 09-217 or 09-219

09-525 Transition Metal Chemistry

Intermittent: 9 units

This class covers fundamental concepts in Transition Metal Chemistry, including coordination numbers and stereochemistry, electronic structure, physical properties, and aspects of chemical reactivity of transition elements and their complexes. Point group theory is used to link the geometric and electronic structures of high symmetry coordination compounds. Analysis of the electronic structure of low symmetry coordination complexes is based on the Angular Overlap Model. In choosing coordination complexes that are discussed in class, special emphasis is given to those that are relevant for the fields of research of students enrolled in the class, such as supramolecular chemistry, nanotechnology, and metal-based catalysis. Students learn about the choice and relevance of modern questions posed by researchers in these fields and the modern methods and techniques used to answer the questions. Students learn also in this course how to use the Cambridge Crystallographic Database, a repository of structural data for more than 200,000 compounds, and how to use Mathematica to solve chemical problems. No prior knowledge of this software is required. (Graduate Course: 12 units, 09-725) 3 hrs. lec.

Prerequisite: 09-348

09-531 Polymer Science

Fall: 9 units

Polymer science is a vibrant multidisciplinary activity. It uses the methods of chemistry, physics, chemical engineering, materials science and biology to create a coherent picture of the macromolecular world. This course is a survey of this field of endeavor suitable for Senior chemistry majors, or other students with a desire for a broad knowledge of the science and engineering of polymers. It covers a thorough description of the field, the synthetic chemistry of macromolecules, the physical chemistry of macromolecules, and the principles of polymer engineering and processing. Prerequisites: (09-219 or 09-217) and (09-345 or 09-214 or 09-347)

09-534 Chemical Approaches to Energy Conversion & Storage

Spring: 9 units

Solar energy and electrical energy from renewable resources need to be stored to resolve intermittency issues. Energy can be stored through charge transfer, changes in chemical bonding, or in electric polarization. This course will introduce students to general aspects of energy-storage technologies using these strategies, integrating scientific and engineering perspectives to discuss thermodynamics, mechanisms of energy storage, and fundamental aspects of efficiency, capacity, and power delivery. Then we will explore current and experimental technologies, covering supercapacitors, batteries, and water-splitting catalysts. By the end of the course, students will be able to apply chemical principles to understand energy-storage technologies and gain knowledge of important classes of these systems. Students enrolled in 09-734 (rather than 09-534) will also be required to write a 15-page NSF style proposal. 3 hrs. lec. Prerequisites: (09-217 or 09-219) and (27-215 or 24-324 or 09-347 or 09-345 or 33-341)

09-535 Applied topics in Macromolecular and Biophysical Techniques

Fall: 9 units

Applications of physical chemistry are widespread. Physical chemical principles are fundamental to the methods used to sequence human genome, obtain high resolution structures of proteins and complex nucleic acids e.g., ribosome, and further provides the framework to predict how molecules fold in 3-dimension, how the different domains interact (inter- and intra-molecular interactions) to perform biological functions. The principles that were discussed in theory in undergraduate physical chemistry classes, will be applied in order to understand the molecular structures and dynamics in nucleic acids and proteins, and to more advanced molecular motors. In the last decade major advances have been made through single-molecule studies that provide finer details of macromolecules in action. This course aims to teach and apply physical chemistry as related to biological problems.

Prerequisites: (09-345 or 09-214 or 09-347) and (03-231 or 03-121 or 03-232)

09-543 Mass Spectrometry: Fundamentals, Instrumentation and Techniques

Intermittent: 6 units

The course is intended for students interested in understanding fundamentals, instrumentation and techniques used in mass spectrometry (MS). The operating principles of various ion sources (EI, CI, PI, ESI, LDI and MALDI), mass analyzers (magnetic, quadrupole, time-of-flight (TOF), ion traps and Fourier transform) and detectors are covered. Applications are focused in the areas of small molecule, proteomics and polymer characterization. Sample preparation, protein identification, peptide sequencing, polymer polydispersity and end group determination are covered. Hyphenated techniques such as GC/MS, LC/MS, and LC/QTOF MS are covered as well as hybrid mass analyzers (e.g., linear ion trap/orbitrap). Various MS scan modes (i.e., SIM, SRM, MS/MS) and basic spectrum interpretation are covered. Students are exposed to QET and RRKM theory and select gas phase reactions. The lecture is supplemented with the use of the "Virtual Mass Spectrometry Laboratory" Internet tool, remote control of mass spectrometers and laboratory. A basic understanding of introductory physics and organic chemistry is expected. 3 hrs. lec., 1.5 hrs. lab.

Prerequisites: 09-214 or 09-345 or 33-341

09-560 Computational Chemistry

Fall: 12 units

Computer modeling is playing an increasingly important role in chemical, biological and materials research. This course provides an overview of computational chemistry techniques including molecular mechanics, molecular dynamics, electronic structure theory and continuum medium approaches. Sufficient theoretical background is provided for students to understand the uses and limitations of each technique. An integral part of the course is hands on experience with state-of-the-art computational chemistry tools running on graphics workstations. 3 hrs. lec.

Prerequisites: 09-344 and 09-345 and 15-110

09-604 Introduction to Chemical Kinetics

Spring: 6 units

Empirical description of the time evolution of chemical reactions. Inductive derivation of kinetic rate laws from actual data. Deductive derivation of kinetic rate laws from proposed mechanisms. Gas phase reactions, catalyzed reactions, enzyme kinetics. Theories of kinetic rate constants for gas phase reactions: unimolecular and bimolecular. Theories of solution phase reactions. Absolute reactions rate theory. Diffusion controlled reactions. Kinetics in highly viscous media. Activation energy and entropy. Volume of activation.

09-611 Chemical Thermodynamics

Fall: 6 units

A focused course on chemical thermodynamics. The basic thermodynamic functions will be introduced and discussed. The formal basis for thermochemistry will be presented. Single component phase equilibrium will be considered. The thermodynamic basis of solutions will be developed and applied to separation methods. The fundamental basis of chemical equilibrium will be developed and applied to a wide variety of reactions. Finally, a few special topics such as self-assembled systems will be presented. This is a graduate level course in chemistry and presumes the appropriate undergraduate preparation.

Prerequisites: 09-345 and 09-231

09-612 Introduction to Quantum Chemistry

Spring: 6 units

This course provides an introduction to quantum principles. The main topics to be covered include the Schrodinger equation, particle in a box, the harmonic oscillator, and the rigid rotor. Applications to vibrational, electronic, and NMR spectroscopy are discussed. Topics in perturbation theory and time-dependent quantum theory are introduced as well.

09-614 Spectroscopy

Intermittent: 6 units

This is a course exclusively in optical methods, both time resolved and steady state. In addition to methodology, spectral interpretation in terms of group theory will be discussed. The time-dependent formalism of quantum mechanics will also be introduced. Molecules in gas phase and condensed phase will be discussed. Frequent use will be made of the current literature. Background consisting of undergraduate physical chemistry is assumed.

This course has a prerequisite 09-344, Quantum Chemistry or permission of the instructor.

09-701 Quantum Chemistry I

Fall: 12 units

The main topics to be covered will include exploration of the Schrodinger equation, operators, particle in the box, harmonic oscillator and hydrogen atom, tunneling, Stern-Gerlach experiment and quantum mechanical postulates, time-independent and time-dependent perturbation theory, matrix diagonalization. The student will learn to master the fundamental concepts and techniques of quantum mechanics. The parallel mini course Mathematical Analysis for Chemistry will provide the necessary mathematical background.

09-702 Statistical Mechanics and Dynamics

Intermittent: 12 units

This course will address the application of statistical mechanics to chemical systems. Topics to be discussed include the calculation of thermodynamic functions, phase transitions and chemical equilibrium, calculation of the transport properties of gases and liquids and the elementary theory of chemical kinetics.

Prerequisites: (09-344 or 09-611) and 09-231 and 09-701

09-705 Chemosensors and Biosensors

Intermittent: 12 units

Chemosensors and biosensors rely on "recognition" and "signaling" elements to transduce a molecular-scale binding event into an observable signal. Students in this course will be introduced to current research and technology for detecting chemical and biological analytes in a variety of contexts, including environmental testing, biological probing and medical diagnostics. Recognition elements ranging from small organic molecules to antibodies will be presented, while various detection modes, including fluorescence, gravimetric and colorimetric, that illustrate different signaling elements will be discussed and compared. Issues to be addressed include sensitivity, selectivity and efficiency. Each sensor will be analyzed in terms of the physical chemistry, organic chemistry and/or biochemistry underlying its function. This is a graduate level course that may also be appropriate for upper level undergraduates in chemistry and the biological sciences. The material in 09-519 or 09-719 would be appropriate background material for this course. 3 hrs. lec.

09-710 Chemistry and Sustainability

Spring: 12 units

This course aims to educate students in the foundations of systematic leadership for building a sustainable world. Many sustainability challenges are associated with commercial chemicals and with operational modes of the chemical enterprise. For scientists, effectiveness in solving the technical challenges and redirecting cultural behavior is the defining substance of sustainability leadership. The course aims to challenge students to analyze and understand the root causes of unsustainability, especially in the technological dimension, to imagine a more sustainable world and to begin to define personal leadership missions. Students will be introduced to sustainability ethics as the foundation stone of transformative sustainability leadership, to the Collins ?Sustainability Compass? and ?Code of Sustainability Ethics? and to the Rob rt/Broman ?Framework for Strategic Sustainable Development (FSSD)? as powerful guiding tools. The Collins ?Bookcase of Green Science Challenges? organizes the technical content. It systematizes the major chemical sustainability challenges of our time: clean synthesis, renewable feed-stocks, safe energy, elemental pollutants, persistent molecular toxicants and endocrine disruptors. Focal areas will be the technical, toxicological and cultural histories of elemental and molecular pollutants and endocrine disruptor (ED) science? EDs represent the single greatest sustainability challenge of everyday chemicals. The graded substance will take the form of take-home work. Students will primarily read key books and articles and will summarize and personally evaluate the material in essay assignments. The course is intended for upper level undergraduates and graduates. There are no other prerequisites. The class is limited to 25 students. The 09-510 assignments are common to both undergraduate and graduate classes offerings and 09-710 students will engage in additional projects. 3 hrs. lec.

Prerequisites: 09-105 or 09-107

09-711 Physical Organic Chemistry

Fall: 12 units

This course introduces students to the study of structure and reactivity of organic compounds from a physical and theoretical standpoint. Students will learn the fundamentals of molecular orbital theory along with some practical applications to aromaticity and anti-aromaticity. Methods are described for the study of reaction mechanisms by means of physical methods such as kinetics, isotope effects, substituent effects, and solvent effects. Important reactive intermediates are described, along with detection methods. This course may be suitable for upper level undergraduates in chemistry with the appropriate background in organic chemistry and physical chemistry. 3 hrs. lec.

Prerequisites: 09-220 and 09-344

09-714 Advanced Organic Chemistry

Spring: 12 units

This course will expose the students to modern methods of organic synthesis including insights into the basis and mechanisms of chemical reactions. Topics include but are not limited to: modern spectroscopic analysis and structure determination, synthetic methods, retrosynthesis, organic reaction mechanisms, and references to separation techniques and some analytical methods. Upon completion of the course students should be able to design reaction schemes using scientific literature sources, evaluate their suitability for use in the lab and develop an aptitude in identifying the use of modern reagents that are more efficient, specific, safer and environmentally friendly. It is assumed that at minimum students will have completed at least two semesters of undergraduate coursework in organic chemistry and suggested that they have completed 09-222 and 09-321, the organic laboratory courses. 3 hrs. lec

Prerequisites: 09-218 or 09-220

09-716 Bioactive Natural Products

Spring: 6 units

This mini-course is aimed at students with an interest in natural products research. Natural products are used as active components in medicinal products, as model compounds for further development into medicinally active drugs, as ingredients in food and for flavor and fragrances, among other very useful and interesting applications. An overview of the structural variety and activity of natural products will be presented along with their isolation and structural determination. Overall, the course will offer an introduction to the work that is customary in natural product research.

This course will cover: Strategies to select the plant or marine material for study; main groups of natural products derived from plants; representative natural products derived from marine organisms; preparation of extracts and selection of active fractions, screening strategies; separation and purification of active components; bench-top bioassays and chemical assays and structure elucidation (especially 2D-NMR spectroscopy) Student's performance will be assessed by weekly assignments on the topics discussed in lecture and by two exams. 3 hrs. lec.

Prerequisites: (09-218 or 09-220) and 09-222

09-720 Physical Inorganic Chemistry

Intermittent: 12 units

This course develops the principles of magnetochemistry and inorganic spectroscopy. Electronic absorption, magnetic circular dichroism, resonance raman, NMR, EPR, Mossbauer, magnetization and x-ray methods will be introduced with application towards the determination of electronic structures of transition metal complexes.

Prerequisites: 09-344 and 09-345 and 09-348

09-721 Bioinorganic Chemistry

Intermittent: 12 units

Many fundamental processes of life require metal ions including: respiration, nitrogen fixation, photosynthesis and replication. This course will treat the basis for the selection and regulation of metal atoms and ligand systems, and the interactions with their corresponding protein environments.

The course will emphasize the chemistry of transition metals and their importance in catalytic processes, atom transfer, and electron transport.

The array of physical methods required for study will be introduced, with application toward the determination of electronic and molecule structure, and enzymatic mechanisms.

Prerequisites: 09-344 and 09-348

09-723 Proximal Probe Techniques: New Tools for Nanoscience & Nanotechnology

Intermittent: 12 units

Proximal probe techniques are revolutionizing physical and biological sciences, owing to their ability to explore and manipulate matter at the nanoscale, and to operate in various environments (including liquids). Proximal probe techniques rely on the use of nanoscale probes, positioned and scanned in the immediate vicinity of the material surface. Their development is often viewed as a first step towards nanotechnology, since they demonstrate the feasibility of building purposeful structures one atom or one (macro)molecule at a time. This course is designed for the students of chemistry, biology physics and engineering, who are interested in the fundamentals of proximal probe techniques and in their applications in various areas, converging into a rapidly developing, interdisciplinary field of nanoscience. It will provide physical background of such basic techniques as Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), and Near-Field Scanning Optical Microscopy (NSOM) and of their variants. Throughout the course, the working "virtual AFM" computer model will be assembled in classroom by each student and then used extensively to gain thorough understanding of AFM operation principles. Particular emphasis will be placed on modes of operation facilitating chemical contrast and contrast based on other material properties. (No prior experience with computer programming required). 3 hrs. lec.

Prerequisites: (09-231 or 21-122 or 21-124) and (09-322 or 09-331 or 09-345 or 09-344)

09-736 Transition Metal Catalysis for Organic and Polymer Synthesis

Intermittent: 12 units

Transition metal catalysts are invaluable in small molecule and polymer synthesis. The course will begin with a brief overview of organometallic chemistry and a discussion of fundamental organometallic reactions.

Following this, a survey of some selected topics for the formation of small molecules and polymers will be presented. Some topics to be highlighted include: (1) Hydrogenation (2) Palladium Catalyzed Cross-Coupling (3) Epoxidation (4) Olefin Metathesis (5) Olefin Polymerization

Prerequisites: (09-218 or 09-220) and 09-348

09-737 Medicinal Chemistry and Drug Development

Fall: 6 units

Organic chemistry is an intimate part of the drug discovery and design processes in areas that include structure determination (NMR, mass spectrometry), synthesis, and determination of mechanisms of action. Once a promising compound (i.e. a "lead") has been identified in the laboratory, it is rarely ready to be used in the clinic. Complications include poor bioavailability, rapid degradation, and off-target effects. Students will learn about lead compound optimization through structural variations, cell-specific targeting and pro-drug strategies. Several examples will be presented to illustrate the role played by organic chemistry in the development of drugs used to treat a range of diseases, including cancer, HIV-AIDS, bacterial infections and heart disease.

Prerequisites: 09-218 or 09-220

09-803 Chemistry of Gene Expression

Intermittent: 12 units

This course examines the chemical basis of biological reactions required for the propagation of genetic information stored in DNA and the organic chemistry principles behind the structure and function of nucleic acids. Main topics of lectures and class discussion will include the chemical and biochemical syntheses, properties and analyses of natural and modified nucleic acids to investigate cellular processes such as transcription, RNA splicing, other RNA regulation and translation; an introduction to the enzymatic strategies that accelerate these chemical reactions and a comparison of protein enzymes, ribozymes and other nucleic acid based enzymes in contemporary chemistry and biology. Students will learn to critically evaluate current scientific efforts that examine various aspects of chemistry and biological chemistry, the relationship between the structure and function of biomolecular systems, propose experiments to examine biological chemistry research problems and communicate these ideas and participate in scientific discussions and debates. 3 hrs. lec.

Prerequisites: 09-518 or 09-718 or (03-442 and 09-218)

09-811 Special Topics in Organic Chemistry and Chemical Biology

Intermittent: 6 units

Students enrolled in this course will learn about nanodevices based on nucleic acids that are capable of detecting - and responding to - changes in their environment. They will discuss the following questions: What real life applications require use of nanodevices? How are the rules to assemble nanodevices similar or dissimilar from those used in the assembly of macro-devices? Are nucleic acids a good material to build nanodevices? What are the rules for building nanodevices from nucleic acids? How do nucleic acid-based nanodevices perform specific functions? These questions will be addressed in in-class and out-of-class analyses of state-of-the-art nanodevices reported in the literature in recent months. In these analyses, the students will use fundamental concepts related to the chemical nature of nucleic acids and to the thermodynamics and kinetics of (1) the Watson-Crick hybridization of nucleic acids, and (2) their interaction with other molecules or ions. As a final project, the students will work in teams to design a new nucleic-acid-based nanodevice.

Prerequisites: 09-218 or 09-220

09-841 Spectroscopy

Intermittent: 12 units

This course emphasizes the use of modern optical methods in the study of molecular properties and reactivity. Basic topics such as the use of group theory in the analysis of vibrational and electronic spectra are covered in detail. In addition, recently developed techniques such as time-resolved and nonlinear spectroscopies are discussed as are applications of optical methods to problems in chemistry, biology and materials science. This course might be appropriate for upper level undergraduate students in chemistry who have the appropriate background in instrumental analysis and physical chemistry.

Prerequisites: 09-344 and 09-345

Civil Environmental Engineering Courses**12-100 Introduction to Civil and Environmental Engineering**

Fall and Spring: 12 units

Introduction to selected subfields in the discipline, such as structural engineering, construction project management, and environmental engineering. Problem-solving exercises apply fundamental concepts from these subfields to integrate the steps of analysis, synthesis, and evaluation through individual homework assignments and group projects that require attention to a broad range of issues. The course also exposes the students to issues related to engineering practice such as working in teams, scheduling, evaluating risk and making ethical decisions. In addition to regular lectures and project exercises, the course includes guest speakers and class demonstrations. 3 hrs., rec., 1 hr. lab.

Corequisites: 33-106 and 21-120

12-201 Geology

Spring: 9 units

Introduction to physical geology; common rocks and rock-forming minerals and their chemical compositions/structure, physical properties, origins, and uses; geologic processes: surface and ground-water flow, volcanism, mountain-building, tectonics, glaciation, sedimentation, seismicity, and atmospheric and oceanic circulation.

12-212 Statics

Fall: 9 units

Introduction to vector mechanics; equivalent systems of forces; equilibrium of rigid bodies; free body diagram; distributed forces, hydrostatic forces, effective forces, centroids; applications to simple statically determinate trusses, beams, frames, cables and other physical systems; friction.

Corequisites: 33-106 and 21-122 and 12-100

12-215 Introduction to Professional Writing in CEE

Spring: 3 units

The objective of the course is to prepare students for writing technical reports and essays assigned in CEE courses and laboratories, writing professional letters and reports for internships, and delivering oral presentations. The course focuses on document purpose, organization and style; basic editing techniques; plagiarism and proper paraphrasing and summarizing; evaluating, citing and referencing sources; oral presentations; and proper use of tables, graphics, and other visual aids in documents and presentations. Course activities include in-class exercises and homework assignments to illustrate examples of good and poor communication and practice technical communication skills. Concurrent with lectures and class activities, students draft and revise a technical report and prepare and deliver a brief oral presentation.

12-231 Solid Mechanics

Spring: 9 units

Analysis of deformable bodies incorporating concepts of stress, strain, mechanical properties of materials, and geometric compatibility. Response under axial loads, torsion, bending, transverse shear, and combined loadings. Stress and strain transformations and Mohr's circles, deflections of beams and shafts, buckling of columns.

Prerequisite: 12-212

Corequisite: 21-259

12-232 Solid Mechanics Lab

Spring: 3 units

Analysis of stress-strain relationships, torsion of solid shafts, deformation due to bending, deformations in three dimensions, Mohr's circle representation of stress and strain, buckling of slender columns. Laboratory experiments and reports associated with theoretical concepts.

Prerequisite: 12-212

Corequisite: 12-231

12-271 Introduction to Computer Application in Civil & Environmental Engineering

Spring: 9 units

Introduction to the use of computer-based applications in civil engineering, using generic tools such as spread-sheets, equation solvers and computer graphics. Discussion of the role of computer-based methods in civil engineering practice.

Prerequisites: 21-120 and 33-106

12-301 Civil Environmental Engineering Projects

Fall: 9 units

Basic elements of civil and environmental engineering projects, from project conception through design, to implementation and operation. Project components are explored through formal instruction combined with analysis of actual engineering projects and student team activities. The role of project management and relevant business concepts are also discussed. The course is intended to develop skills and understanding related to the application of engineering and science principles, approximations, empiricism, and experience to engineering projects and public policy issues related to projects; basic theory and practice of design; the importance and challenge of team efforts; leadership, individual and group ethical behavior and effective communication; and the utility of measurements, modeling, visualization, quality control, and engineering graphics.

Prerequisites: 12-212 and 12-271

12-335 Soil Mechanics

Fall: 9 units

Sampling, testing and identification of soils. Physical, chemical and hydraulic characteristics. Stress-strain-strength relationships for soils. Permeability, seepage, consolidation, and shear strength, with applications to deformation and stability problems, including earth dams, foundations, retaining walls, slopes and landfills.

Prerequisites: 12-231 and 33-107

Corequisite: 12-355

12-336 Soil Mechanics Laboratory

Fall: 3 units

Examination of material properties and behavior of soils. Experiments include soil classification, permeability, compaction, consolidation and strength tests.

Prerequisite: 12-231

Corequisite: 12-335

12-351 Environmental Engineering

Spring: 9 units

Provides a scientific and engineering basis for understanding environmental issues and problems. Introduces material and energy balances for tracking substances in the atmosphere, source and ground waters, and soil systems. Pertinent environmental laws are described, simple quantitative engineering models are developed, and qualitative descriptions of environmental engineering control technologies are presented.

Prerequisites: 09-105 and 12-355 and 21-260

12-352 Environmental Engineering Lab

Spring: 3 units

(Required for CEE students, not for others) Laboratory and field experiments that illustrate the basic principles of environmental engineering.

Corequisite: 12-351

12-355 Fluid Mechanics

Fall: 9 units

Fluid characteristics; continuity, momentum and energy equations; dynamic similitude; laminar and turbulent boundary layers; flow in pipes; lift and drag on immersed bodies; open channel flow.

Prerequisites: 21-259 and 21-260

12-356 Fluid Mechanics Lab

Fall: 3 units

Fluid properties: density, specific gravity, viscosity; fluid characteristics; continuity, conservation of energy; fluid behavior: center of pressure, pipe flow, open-channel flow. Laboratory experiments illustrating basic principles. Corequisite: 12-355

12-358 Materials Lab

Spring: 3 units

Examination of materials properties and behavior of concrete, masonry, and timber.

Prerequisite: 27-357

12-401 Civil & Environmental Engineering Design

Fall: 15 units

Methodology for formulating and solving design problems, characterized by incomplete specifications, open-ended solution space, and partial evaluations. The methodology is illustrated and applied in the context of realistic design problems drawn from civil and environmental engineering. Design projects performed by teams, emphasizing collaborative problem-solving and preparation of written and oral reports. The importance of ethics, life long learning, and professional licensure are also discussed. Senior Standing in Civil and Environmental Engineering or instructor approval for Design Minors. Corequisite: 12-301, 12-6xx 9 unit course Corequisite: 12-301

12-411 Project Management for Construction

Fall: 9 units

Introduction to construction project management from owner's perspective in organizing planning, design, construction and operation as an integrated process. Examination of labor productivity, material management and equipment utilization. Cost estimation and financing of constructed facilities. Contracting, construction planning and fundamental scheduling procedures. Cost control, monitoring and accounting for construction.

Prerequisite: 21-120

12-421 Engineering Economics

Fall: 6 units

Basic concepts of economic analysis and evaluation of alternative engineering projects for capital investment. Consideration of time value of money and common merit measures such as net present value and internal rate of return. Selection of independent projects and mutually exclusive proposals, using various methods of analysis. Capital budgeting and project financing. Influence of price level changes, depreciation and taxation on choice of alternatives. Uncertainty and risk in operation and financing. Important factors affecting investment decisions for private and public projects. Senior Standing in Civil Engineering or approval of instructor.

Prerequisite: 21-120

12-600 AutoCAD

Fall: 3 units

Fall 2015 AutoCAD will be a mostly online course. The course provides an introduction to the fundamentals of computer-aided design (CAD) software. Students learn how to set up CAD projects using Autodesk's AutoCAD software. Topics include coordinates, lines, circles, arcs, zooms, snaps and grids, text, views, layers, plines, blocks, reference files, dimensioning, isometrics, 3D commands, surfaces, solids, and more. CAD standards for layers, plotting, and symbol libraries are also covered. The course includes development of a CAD project by each student.

12-604 Transportation Engineering

Spring: 9 units

Introduction to traffic engineering and highway design providing practical experience that can be used directly in the workforce. Course material will provide a solid foundation in preparing for the Professional Engineer exam. The course incorporates the "soft" side of transportation engineering with tasks such as traffic analyses and traffic studies and the "hard" side of transportation engineering including traffic signal design, signing design, pavement marking design, maintenance and protection of traffic during construction design, and highway design.

12-610 Special Topic: Intl Collaborative Construction Mgmt

Spring: 9 units

This course is intended to provide a comprehensive overview of the life cycle of the facility development process and of relevant project management techniques. While primary emphasis is on the construction phase, the techniques and perspective apply to the other phases of the facility development process as well. Students learn not only how to develop construction estimates and schedules, but also, globalization issues, methods to work on multicultural teams, negotiation techniques, and methods to improve international collaboration enhanced by the use of Information Technology. Students work in international teams to collaborate from remote locations via the Internet taking maximum advantage of information technology using commercially available software. Students also report on lessons learned on working with different cultures.

12-629 Environmental Microbiology for Engineers

Fall: 9 units

This class provides a general introduction to microorganisms in natural and engineered environments. Selected topics include: cellular architecture, energetics and energy conservation, growth and catabolism; evolution and genetics; population and community dynamics; water and soil microbiology; biogeochemical cycling; biofilms; and microorganisms in wastewater, pollution attenuation, and bioremediation.

Prerequisite: 03-121

12-631 Structural Design

Spring: 12 units

Design of structural members for bending moment, shear force, axial force, and combined axial force and bending. Reinforced concrete, structural steel, and composite beam construction are considered. Buckling effects in columns, beams and local plate segments are treated. Serviceability limits such as deflection and cracking are addressed. Design projects include the determination of loads and the selection of system geometry.

Prerequisite: 12-231

Corequisites: 27-357 and 12-358

12-635 Structural Analysis

Fall: 9 units

Classical and matrix-based methods of structural analysis; energy principles in structural mechanics. Basic concepts of force and displacement methods for analyzing redundant structural systems. Matrix methods utilizing the flexibility (force) and stiffness (displacement) concepts.

Prerequisite: 12-231

12-636 Geotechnical Engineering

Spring: 9 units

Behavior of geotechnical structures; engineering design of geotechnical structures considering failure modes; uncertainties; economic issues, required design formats and relevant code provisions; performance requirements for foundations, subsurface investigations; allowable stress and LRFD design approaches; reliability-based design; shallow foundations; deep foundations; retaining structures; reinforced concrete foundations.

Prerequisite: 12-335

12-648 CEE Senior Research Project

Fall and Spring

This course is designed to give students the opportunity to work on an open-ended project under the direction of a faculty member in the Civil & Environmental Engineering department. To register for this course, a student must have the approval of the faculty member for both the research topic and the number of units. A student in this course must write a proposal and submit progress reports to the advisor. The student must also make a formal presentation of the project results and submit a final report to the department. Senior standing in CEE and permission of the project advisor Units: 9-12

12-651 Air Quality Engineering

Fall: 9 units

The course provides a quantitative introduction to the processes that control atmospheric pollutants and the use of mass balance models to predict pollutant concentrations. We survey major processes including emission rates, atmospheric dispersion, chemistry, and deposition. The course includes discussion of basic atmospheric science and meteorology to support understanding air pollution behavior. Concepts in this area include vertical structure of the atmosphere, atmospheric general circulation, atmospheric stability, and boundary layer turbulence. The course also discusses briefly the negative impacts of air pollution on society and the regulatory framework for controlling pollution in the United States. The principles taught are applicable to a wide variety of air pollutants but special focus is given to tropospheric ozone and particulate matter. The course is intended for graduate students as well as advanced undergraduates. It assumes a knowledge of mass balances, fluid mechanics, chemistry, and statistics typical of an undergraduate engineer but is open to students from other scientific disciplines.

12-657 Water Resource Systems Engineering

Spring: 9 units

Principles and applications of open channel flow. Hydrology of surface and ground water sources and the estimation of water requirements. Planning and design of water distribution and wastewater and storm water collection systems. This course is offered every other spring semester.

Prerequisite: 12-355

Corequisite: 12-351

12-658 Hydraulic Structures

Spring: 9 units

Theory and practice of design of riverine and coastal structures, including dams, levees, bridge piers, culverts, jetties and groins, seawalls, bulkheads, breakwaters, marinas, and harbors. Key related concepts from surface and ground water hydrology, and wave mechanics. This course is offered every other spring semester.

Corequisite: 12-355

12-659 Special Topics: Matlab

Fall: 6 units

This mini course is designed to be a practical introduction to engineering scientific computation. The topics of this class will include basic matrix computation, solving ordinary and partial differential equations, solving systems of linear equations, computing eigenvalues and eigenvectors, and basic signal processing and neural network techniques. Throughout the course, these scientific computation tools will be demonstrated using interactive scientific software called MATLAB.

12-679 Special Topics: Intro to Meteorology

Fall: 12 units

The course targets entering doctoral students in atmospheric research, as well as interested upper-level undergraduates (juniors and seniors) and masters students across engineering and sciences. It will provide students with the basics of meteorology, with a focus on large-scale atmospheric motion. By the end of the term students will understand the basics of atmospheric dynamics, including horizontal and vertical motion, as well as the vertical structure of the atmosphere (atmospheric stability and boundary-layer dynamics). They will understand what makes weather happen and they will understand weather maps and charts. They will be able to critically watch the nightly weather forecast and be able to access available meteorological databases to make informed predictions of their own. Finally, they will understand atmospheric transport and boundary-layer dynamics, which will serve as a foundation for other coursework involving atmospheric transport and air-pollution if they are pursuing those topics more deeply.

12-686 Special Topics: Computational Materials Modeling for Structures

Spring: 12 units

The course examines current mathematical models for the macroscopic response of metals, rocks, soil, and polymers and how they are motivated; elements of the microscopic basis that can be assigned to such models; and methods for finite element implementations of such models. Undergraduate mechanics background, familiarity with basic tensor algebra and calculus and the equations of 2-d elasticity theory, and some exposure to the finite element method (or a strong desire to learn these topics by guided self-study) are assumed.

12-690 Independent Study

Fall and Spring

In-depth investigation of a special topic in Civil and Environmental Engineering under the direction of a faculty member. The topic usually involves open-ended problems whose solution requires some elements of syntheses, analysis, construction, testing and evaluation of an engineering device or system. Junior or Senior Standing or with instructor permission in Civil and Environmental Engineering. Faculty approval required. 3 to 12 units

12-702 Fundamentals of Water Quality Engineering

Fall: 12 units

This course is a systematic overview of water quality engineering designed for students with no prior civil and environmental engineering background. Topics examined include physical, chemical, and biological characteristics of water; common water pollutants; basic water chemistry and microbiology; mass and energy balances and their use in reactor analysis; physical, chemical and biological processes affecting natural water quality and the use of these processes in water supply and wastewater management systems; and selected problems in surface water and groundwater quality management. A background in college-level general chemistry, physics, calculus, and differential equations is assumed.

12-704 Probability and Estimation Methods for Engineering Systems

Fall: 12 units

Overview of rules of probability, random variables, probability distribution functions, and random processes. Techniques for estimating the parameters of probability models and related statistical inference. Application to the analysis and design of engineered systems under conditions of variability and uncertainty.

12-712 Introduction to Sustainable Engineering

Fall: 12 units

This course begins with an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the twentieth century. Models for population growth, global food production, and global water resources are then presented, and current problems such as land use, urbanization, and energy and material resources are discussed. Models of industry based on life sciences are then explored, and tools for sustainable engineering are presented. These tools include metrics of sustainability, principles of design for the environment, methods for pollution prevention, and use of mass and energy balances in the design of sustainable systems. Prerequisite: senior/graduate standing in engineering or permission of the instructor.

12-714 Environmental Life Cycle Assessment

Spring: 12 units

Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes using the ISO 14040 family of standards. This includes goal and scoping definition, inventory analysis, life cycle impact assessment (LCIA), interpretation, and guidance for decision support. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software such as MATLAB, Excel, and Simapro are introduced and used in assignments. A group life cycle assessment project consistent with the principles and tools of sustainability to solve real-world engineering problems is required.

Prerequisites: (12-421 or 12-706) and 12-712

12-718 Environmental Engineering, Sustainability, and Science Project

Spring: 12 units

This course integrates and exercises students in a significant sustainable engineering and/or environmental project that is team-based and built upon the knowledge, skills, and technologies learned in the core and specialist courses in the EESS graduate curriculum.

12-720 Water Resources Chemistry

Fall: 12 units

This course provides a rigorous yet practical basis for applying the principles of physical chemistry to understanding the composition of natural waters and to the engineering of water and wastewater treatment processes. Topics covered include chemical equilibrium and kinetics; acid-base equilibria and buffering; solid precipitation and dissolution; oxidation and reduction reactions; adsorption on solids; and computer-aided problem solving. The primary objective of the course is to be able to formulate and solve chemical equilibrium models for complex aqueous systems. Knowledge of college-level general chemistry is assumed.

12-725 Fate, Transport & Physicochemical Processes of Organic Contaminants in Aquatic Systems

Spring: 12 units

Examination of the major physical and chemical processes affecting the fate and treatment of organic compounds and nanoparticles in aquatic systems. The emphasis is on anthropogenic organic compounds. The course will review some concepts from physical organic chemistry, and examine the relationships between chemical structure, properties, and environmental behavior of organic compounds. Chemical processes important to the fate, treatment, and biotransformation of specific organic compounds are addressed. Two laboratory sessions illustrate measurement techniques for organic compounds in water. 12-702 is a co-req for non environmental engineers or students who have not had an environmental engineering undergraduate course

12-734 Special Topics: Structural Health Monitoring

Spring: 6 units

Structural health monitoring system, which enables us to automatically diagnose and prognose structural damage, is important to ensure safe and functional built environment. This area requires a multi-disciplinary approach that encompasses structural engineering, sensor technology, wireless communication, signal processing, and statistical analysis. This course introduces damage diagnosis algorithms using various model-based and signal-based methods for civil structures with an emphasis on the underlying physical interpretations and their practical usage. The methods include modal analysis, time-series modeling, Gaussian mixture modeling, hypothesis testing, frequency analysis, and various classification techniques. The course is lecture-based with assignments and a project. You will have an opportunity through a class project to explore various damage diagnosis algorithms, choose one to implement, present your work to the class, and be peer-reviewed.

12-740 Data Acquisition

Fall: 6 units

The intent of this course is to introduce students to the concepts, approaches and implementation issues associated with data acquisition for infrastructure systems. Students will be introduced to the types of data that is collected about infrastructure systems, excitation mechanisms, sensing technologies, data acquisition using sensors, signal pre-processing and post-processing techniques, and use of sensing in a variety of applications in construction and infrastructure management. Students will also gain experience with data acquisition hardware and software.

12-741 Data Management

Fall: 6 units

The intent of this course is to introduce students to database management systems and to knowledge discovery in database principles. Students will learn how to develop powerful tools for efficiently managing large amounts of civil engineering data so that it may persist safely over long periods of time. Students will be introduced to relational database systems and structured query languages. They will also be exposed to other existing data models. Students also will be introduced to data mining and analysis tools to discover patterns and knowledge from data.

12-746 Special Topics: Fundamental Python Prototyping for Infrastructure Systems

Fall: 6 units

This course uses the Python programming language to introduce fundamental programming approaches to students from civil and environmental engineering. No prerequisite required and students with no programming experience are recommended to take this course. This course will cover fundamental programming approaches, object-oriented programming concepts, graphical user interface design in Python, and file and database operation. Real-world examples from infrastructure management will be used in the class for demonstration and term project. Students will work individually and in teams to develop a series of applications that are potentially be used in real-world applications.

12-747 Special Topics: Sustainable Buildings

Fall: 6 units

This course will cover the basics of the design, retrofit and monitoring of buildings to achieve energy efficiency. We will introduce energy simulation tools, the fundamentals of the most important building systems (i.e., heating, cooling, ventilation, insulation, etc.) and the technologies that can be used to monitor their performance.

12-748 Special Topics: Mechanical and Electrical System Design for Buildings

Fall: 6 units

Class will cover HVAC, Electrical, and Plumbing systems for buildings. We will calculate heat loss and heat gains manually and with computer programs and calculate operating costs with various fuels and system types. We will size building electrical systems and look at alternative generation, smart metering and new lighting systems. Plumbing will include sizing water, drain and vent lines along with system design. Focus of the class will be on energy conservation and use, and how future systems will meet these criteria. The final project will be the audit of a building on campus using what we learned.

12-749 Special Topics: Climate Change Adaptation

Fall: 6 units

While the specific timing and magnitude of climate change impacts are uncertain, long-lived civil engineering infrastructure will need to be resilient to these potential impacts. Engineers designing for climate change adaptation require the tools to maximize resiliency and minimize cost for existing and proposed energy, transportation, water, urban and other types of infrastructure. Students successfully completing this course will understand how climate change affects civil infrastructure and how to quantitatively incorporate resilient designs and co-benefits under uncertainty. Students will use open data to examine current adaptation engineering challenges, quantify solutions, and communicate their technical recommendations through policy briefs. Prerequisites: Graduate standing or consent of instructor.

12-752 Special Topics: Data-Driven Building Energy Management

Fall: 6 units

This course will introduce students to a variety of data acquisition and analysis techniques required to solve the challenges faced by facility managers when trying to optimize the performance of our existing building stock. The course assumes students are familiar with concepts in instrumentation, linear algebra, probability, statistics and programming, though this is not a strict requirement. Some of the specific topics that will be discussed include: non-intrusive load monitoring, direct load control for demand response and automatic localization of sensors in buildings. Prerequisite: 12-740

12-755 Finite Elements in Mechanics I

Fall: 12 units

The basic theory and applications of the finite element method in mechanics are presented. Development of the FEM as a Galerkin method for numerical solution of boundary value problems. Applications to second-order steady problems, including heat conduction, elasticity, convective transport, viscous flow, and others. Introduction to advanced topics, including fourth-order equations, time dependence, and nonlinear problems. Prerequisite: Graduate standing or consent of instructor. Prerequisites: Graduate standing or consent of instructor.

12-765 Special Topics: International Climate Adaptation & Infrastructure Innovation

Fall: 6 units

Although an international problem, climate change will affect each country's critical infrastructure in diverse ways. This course will focus on understanding how international communities are adapting and innovating to reduce critical infrastructure risk. Students will be able to list and describe natural hazards affected by climate change, focusing on their impacts on natural and built critical infrastructure systems in physically, socially, and economically diverse countries. Students will then use cost-benefit analysis, the triple bottom line approach (physical, social, economic), and robust decision making to analyze, compare, and contrast different countries' responses. The class will culminate in a final paper and presentation on one country's approach to decision-making under uncertainty for adaptation. Learning Objectives: By the end of the semester, you should be able to:

- Understand risk.
- Define risk, hazard, vulnerability, exposure, adaptation, hazard mitigation, greenhouse gas mitigation.
- Explain the link between some natural hazards and climate change.
- List 10 natural hazards and their impacts on the international community.
- Analyze outcomes/impacts.
- Predict how physically, socially, and economically detrimental a given natural hazard will actually be in different critical infrastructure systems.
- Compare and contrast different adaptations to reduce risk.
- Create recommendations for improving adaptation in an international community.

12-769 Continuum Mechanics of Materials

Fall: 12 units

The topics that shall be covered are (1) An overview of Cartesian tensors, (2) Kinematics and Deformation, (3) Conservation Principles, (4) Constitutive Relations for Fluids and Solids and Boundary Value Problems, and (5) Dynamics of Continuum Systems. An undergraduate background in mechanics, including statics, dynamics, and solid mechanics is assumed, as well as a background that includes multivariable integral and differential calculus. Prerequisites: Graduate standing or permission of instructor
Corequisite: 24-751 - Intro to Solid Mechanics I

12-772 Inelasticity

Fall: 12 units

The first part of the course focuses on a theoretical framework for describing the macroscopic inelastic response of common materials like metals and polymers. The second part deals with computational approximation of such a framework within the finite element method. Topics: Theory? Physical origin of plasticity, stress-strain curve, yielding, work-hardening. Small and Finite-deformation theory? constitutive structure, normality; Hill's method of principal axes?, work-conjugate stress measures corresponding to arbitrary strain measures, formulation of the boundary value problem of incremental equilibrium and analysis of uniqueness for rate-(in)dependent materials. Computational Algorithms? isotropic hyperelasticity and hypoelasticity; rate-(in)dependent plasticity within the additive and multiplicative decompositions; linear and nonlinear viscoelasticity? material updates with exact/second-order accurate linearizations; incremental objectivity for hypoelasticity and finite plasticity under additive decomposition; element formulation to deal with near incompressibility. Exposure to graduate level introductory solid mechanics, finite element method, and continuum mechanics is desirable.

12-784 Special Topics:Advanced Multiscale Modeling & Computation Engineering Materials

Fall: 12 units

This course will deal with advanced topics in multiscale modeling. Specific topics will vary depending on student and instructor interest, but will be in the general area of theoretical analysis of multiscale problems, and application of the theoretical analysis to develop efficient numerical methods for such problems. The material presented will be at a level that assumes that students have a strong grounding in graduate level finite element methods, solid mechanics, continuum mechanics, and engineering mathematics.

Prerequisites: 12-769 and (12-755 or 24-751)

12-798 Special Topics: Professional Communication for CEE Grad Students

Fall: 3 units

The course reviews skills and techniques for preparing technical documents, professional letters, resumes, and presentations typically encountered in advanced degree programs and in research and development positions in the public and private sector. Class topics focus on document purpose and organization; researching technical sources; summarizing, paraphrasing, and citing sources; simplifying and revising techniques; and the proper use of tables, graphics, and other visual aids in documents and oral presentations. Course content emphasizes North American writing norms. Attendance at the required seminar on academic integrity and ethics in writing for CEE graduate students is also a requirement of this course.

Computational Biology Courses

02-201 Programming for Scientists

Fall and Summer: 12 units

Provides a practical introduction to programming for students with little or no prior programming experience. Extensive programming assignments will illustrate programming concepts, languages, and tools. Programming assignments will be based on analytical tasks that might be faced by scientists and will typically include parsing, statistical analysis, simulation, and optimization. Principles of good software engineering will also be stressed. Most programming assignments will be done in the Go programming language, an industry-supported, modern programming language, the syntax of which will be covered in depth. Several other assignments will be given in other programming languages such as Python and Java to highlight the commonalities and differences between languages. No prior programming experience is assumed, and no biology background is needed. Analytical skills and mathematical maturity are required. Course not open to CS majors.

02-223 Personalized Medicine: Understanding Your Own Genome

Fall: 9 units

Do you want to know how to discover the tendencies hidden in your genome? Since the first draft of a human genome sequence became available about a decade ago, the cost of genome sequencing has decreased dramatically. Personal genome sequencing will likely become a routine part of medical exams for patients for prognostic and diagnostic purposes. Personal genome information will also play an increasing role in lifestyle choices, as people take into account their own genetic tendencies. Commercial services such as 23andMe have already taken first steps in this direction. Computational methods for mining large-scale genome data are being developed to unravel the genetic basis of diseases and assist doctors in clinics. This course introduces students to biological, computational, and ethical issues concerning use of personal genome information in health maintenance, medical practice, biomedical research, and policymaking. We focus on practical issues, using individual genome sequences (such as that of Nobel prize winner James Watson) and other population-level genome data. Without requiring any background in biology or CS, we begin with an overview of topics from genetics, molecular biology, stats, and machine learning relevant to the modern personal genome era. We then cover scientific issues such as how to discover your genetic ancestry and how to learn from genomes about migration and evolution of human populations. We discuss medical aspects such as how to predict whether you will develop diseases such as diabetes based on your own genome, how to discover disease-causing genetic mutations, and how genetic information can be used to recommend clinical treatments.

02-250 Introduction to Computational Biology

Spring: 12 units

This 12-unit class provides a general introduction to computational tools for biology. The course is divided into two modules, which may be taken individually as courses 02-251 and 02-252. Module 1 covers computational molecular biology/genomics. It examines important sources of biological data, how they are archived and made available to researchers, and what computational tools are available to use them effectively in research. In the process, it covers basic concepts in statistics, mathematics, and computer science needed to effectively use these resources and understand their results. Specific topics covered include sequence data, searching and alignment, structural data, genome sequencing, genome analysis, genetic variation, gene and protein expression, and biological networks and pathways. Module 2 covers computational cell biology, including biological modeling and image analysis. It includes homeworks requiring modification of scripts to perform computational analyses. The modeling component includes computer models of population dynamics, biochemical kinetics, cell pathways, neuron behavior, and stochastic simulations. The imaging component includes basics of machine vision, morphological image analysis, image classification and image-derived models. Lectures and examinations are joint with 03-250 but recitations are separate. Recitations for this course are intended primarily for computer science, statistics or engineering majors at the undergraduate or graduate level who have had significant prior experience with computer science or programming. Students may not take both 02-250/03-250 and either 02-251/03-251 or 02-252/03-252 for credit. Prerequisite: 03-121

02-251 Introduction to Computational Molecular Biology

Spring: 6 units

This 6-unit miniclass provides a general introduction to computational tools for biology with specific emphasis on molecular biology and genomics. Along with 02-252, it makes up one half of the full Introduction to Computational Biology, 02-250, although either half can be taken individually. 02-251 examines important sources of biological data, how they are archived and made available to researchers, and what computational tools are available to use them effectively in research. In the process, it covers basic concepts in statistics, mathematics, and computer science needed to effectively use these resources and understand their results. Specific topics to be covered include sequence data, searching and alignment, structural data, genome sequencing, genome analysis, genetic variation, gene and protein expression, and biological networks and pathways. Lectures and examinations are joint with 03-251 but recitations are separate. Recitations for this course are intended primarily for computer science, statistics or engineering majors at the undergraduate or graduate level who have had significant prior experience with computer science or programming. Students may not take both 02-251/03-251 and 02-250/03-250 for credit. Prerequisite: 03-121

02-252 Introduction to Computational Cell Biology

Spring: 6 units

This 6-unit minicourse presents an overview of important modeling and image analysis applications of computers to solve problems in cell biology. Along with 02-251, it makes up one half of the full Introduction to Computational Biology, 02-250, although either half can be taken individually. Major topics covered are computer models of population dynamics, biochemical kinetics, cell pathways, neuron behavior, and stochastic simulations. The imaging component includes basics of machine vision, morphological image analysis, image classification and image-derived models. It includes homeworks requiring modification of scripts to perform computational analyses. Lectures and examinations are joint with 02-252 but recitations are separate. Recitations for this course are intended primarily for computer science, statistics or engineering majors at the undergraduate or graduate level who have had significant prior experience with computer science or programming. Students may not take both 02-252/03-252 and 02-250/03-250 for credit.

Prerequisite: 03-121

02-261 Quantitative Cell and Molecular Biology Laboratory

Fall: 9 units

This is an introductory laboratory-based course designed to teach basic biological laboratory skills used in exploring the quantitative nature of biological systems and the reasoning required for performing research in computational biology. Over the course of the semester, students will perform many experiments and quantitatively analyze the results of these experiments. Students will also have the opportunity to design experiments based on the data they collect. During this course students will be using traditional, well-developed techniques to answer open questions. What microbes are found in the food we eat? What changes do cells undergo during apoptosis? Understanding the results of these experiments will require students to think critically about the results they generate, the appropriate controls required to confirm results, and the biological context within which these results were obtained. During this course students will gain experience in many aspects of scientific research, including: Sequencing and analyzing a large and diverse population of DNA, Designing and performing PCR for a variety of analyses, Maintaining cell cultures, Taking brightfield and fluorescent microscopy images, Developing methods for automated analysis of cell images, Communicating results to peers and colleagues. As space is limited, laboratory sections will be small. Additional sections will be added to accommodate all students on the waitlist. Course Outline: (1) 3-hour lab per week (1) 2-hour lecture per week. 9 units.

02-317 Algorithms in Nature

Fall: 9 units

Computer systems and biological processes often rely on networks of interacting entities to reach joint decisions, coordinate and respond to inputs. There are many similarities in the goals and strategies of biological and computational systems which suggest that each can learn from the other. These include the distributed nature of the networks (in biology molecules, cells, or organisms often operate without central control), the ability to successfully handle failures and attacks on a subset of the nodes, modularity and the ability to reuse certain components or sub-networks in multiple applications and the use of stochasticity in biology and randomized algorithms in computer science. In this course we will start by discussing classic biologically motivated algorithms including neural networks (inspired by the brain), genetic algorithms (sequence evolution), non-negative matrix factorization (signal processing in the brain), and search optimization (ant colony formation). We will then continue to discuss more recent bi-directional studies that have relied on biological processes to solve routing and synchronization problems, discover Maximal Independent Sets (MIS), and design robust and fault tolerant networks. In the second part of the class students will read and present new research in this area. Students will also work in groups on a final project in which they develop and test a new biologically inspired algorithm. See also: www.algorithmsinnature.org Pre-requisite: 15-210, no prior biological knowledge required. Prerequisites: 15-251 and 15-210

02-402 Computational Biology Seminar

Fall and Spring: 3 units

This course consists of weekly invited presentations on current computational biology research topics by leading scientists.

02-403 Special Topics in Bioinformatics and Computational Biology

Intermittent: 6 units

A decade ago, mass spectrometry (MS) was merely a qualitative research technique allowing the analysis of samples regarding the presence of specific biomolecules. However, as MS has turned quantitative, more sophisticated experiments can be performed, such as the recording of signal transduction kinetics and the analysis of the composition of protein complexes and organelles. This makes MS-based proteomics a powerful method to study spatiotemporal protein dynamics. The development of relative quantification approaches, which generally use ²H, ¹³C or ¹⁵N isotope labels, has especially led to an increase in quantification accuracy and set off numerous new experimental approaches to study protein regulation. In this mini-course, we will cover mass spectrometry principles, discuss classical as well as current primary literature addressing method development and quantitative analysis, and highlight state-of-the-art biological studies that employ MS. A combination of lectures, student presentations, and written exercises will establish a thorough knowledge of current bio-analytical MS approaches.

Prerequisites: (03-250 or 02-250) and 03-121

02-404 Special Topics in Bioinformatics and Computational Biology: Adv. Phage Genomics

Intermittent

This course is offered occasionally and focuses on a different topic each time. It typically consists of a combination of lectures introducing an important area of computational biology research followed by critical reading and presentation of papers from the literature in the area by students. Grading is based on class participation and occasional written assignments. Prerequisites: 03-121 and 02-250/03-250 or permission of instructor.

02-421 Algorithms for Computational Structural Biology

Intermittent: 12 units

Some of the most interesting and difficult challenges in computational biology and bioinformatics arise from the determination, manipulation, or exploitation of molecular structures. This course will survey these challenges and present a variety of computational methods for addressing them. Topics will include: molecular dynamics simulations, computer-aided drug design, and computer-aided protein design. The course is appropriate for both students with backgrounds in computer science and those in the life sciences.

02-422 Advanced Algorithms for Computational Structural Biology

Fall: 9 units

Missing Course Description - please contact the teaching department.

02-450 Automation of Biological Research

Fall: 9 units

Biology is increasingly becoming a "big data" science, as biomedical research has been revolutionized by automated methods for generating large amounts of data on diverse biological processes. Integration of data from many types of experiments is required to construct detailed, predictive models of cell, tissue or organism behaviors, and the complexity of the systems suggests that these models need to be constructed automatically. This requires iterative cycles of acquisition, analysis, modeling, and experimental design, since it is not feasible to do all possible biological experiments. This course will cover a range of automated biological research methods and a range of computational methods for automating the acquisition and interpretation of the data (especially active learning, proactive learning, compressed sensing and model structure learning). Grading will be based on class participation, homeworks, and a final project. The course is designed for graduate and upper-level undergraduate students with a wide variety of backgrounds. The course is intended to be self-contained but students may need to do some additional work to gain fluency in core concepts. Students should have a basic knowledge of biology, statistics, and programming. Experience with Machine Learning is useful but not mandatory. Prerequisite: 15-122

Course Website: <http://lane.compbio.cmu.edu/courses/automationbioresearch>**02-500 Undergraduate Research in Computational Biology**

Fall and Spring

This course is for undergraduate students who wish to do supervised research for academic credit with a Computational Biology faculty member. Interested students should first contact the Professor with whom they would like to work. If there is mutual interest, the Professor will direct you to the Academic Programs Coordinator who will enroll you in the course.

02-510 Computational Genomics

Spring: 12 units

Dramatic advances in experimental technology and computational analysis are fundamentally transforming the basic nature and goal of biological research. The emergence of new frontiers in biology, such as evolutionary genomics and systems biology is demanding new methodologies that can confront quantitative issues of substantial computational and mathematical sophistication. In this course we will discuss classical approaches and latest methodological advances in the context of the following biological problems: 1) Computational genomics, focusing on gene finding, motifs detection and sequence evolution. 2) Analysis of high throughput biological data, such as gene expression data, focusing on issues ranging from data acquisition to pattern recognition and classification. 3) Molecular and regulatory evolution, focusing on phylogenetic inference and regulatory network evolution, and 4) Systems biology, concerning how to combine sequence, expression and other biological data sources to infer the structure and function of different systems in the cell. From the computational side this course focuses on modern machine learning methodologies for computational problems in molecular biology and genetics, including probabilistic modeling, inference and learning algorithms, pattern recognition, data integration, time series analysis, active learning, etc.

02-512 Computational Methods for Biological Modeling and Simulation

Fall: 9 units

This course covers a variety of computational methods important for modeling and simulation of biological systems. It is intended for graduates and advanced undergraduates with either biological or computational backgrounds who are interested in developing computer models and simulations of biological systems. The course will emphasize practical algorithms and algorithm design methods drawn from various disciplines of computer science and applied mathematics that are useful in biological applications. The general topics covered will be models for optimization problems, simulation and sampling, and parameter tuning. Course work will include problems sets with significant programming components and independent or group final projects.

Prerequisites: 03-121 and (02-201 or 15-122 or 02-601)

02-513 Algorithms and Data Structures for Scientists

Spring: 12 units

Introduction to design and analysis of algorithms and data structures. Emphasis placed on techniques that are useful for the analysis of scientific data. Topics include dynamic programming, linear programming, network flows, local and heuristic search, and randomization. NP-completeness and approximation algorithms will also be covered. Data structures discussed will include balanced trees, priority queues, trees for geometric data, string data structures, and hashing. Minimal previous algorithmic knowledge is assumed. Classwork may include programming assignments, but strong programming skills not required. This course is not open to CS majors.

02-514 String Algorithms

Fall: 12 units

Provides an in-depth look at modern algorithms used to process string data, particularly those relevant to genomics. The course will cover the design and analysis of efficient algorithms for processing enormous collections of strings. Topics will include string search; inexact matching; string compression; string data structures such as suffix trees, suffix arrays, and searchable compressed indices; and the Burrows-Wheeler transform. Applications of these techniques in biology will be presented, including genome assembly, transcript assembly, whole-genome alignment, gene expression quantification, read mapping, and search of large sequence databases. No knowledge of biology is assumed, and the topics covered will be of use in other fields involving large collections of strings. Programming proficiency is required.

Course Website: <http://www.cs.cmu.edu/~ckingsf/class/02-714>**02-530 Cell and Systems Modeling**

Spring: 12 units

This course will introduce students to the theory and practice of modeling biological systems from the molecular to the organism level with an emphasis on intracellular processes. Topics covered include kinetic and equilibrium descriptions of biological processes, systematic approaches to model building and parameter estimation, analysis of biochemical circuits modeled as differential equations, modeling the effects of noise using stochastic methods, modeling spatial effects, and modeling at higher levels of abstraction or scale using logical or agent-based approaches. A range of biological models and applications will be considered including gene regulatory networks, cell signaling, and cell cycle regulation. Weekly lab sessions will provide students hands-on experience with methods and models presented in class. Course requirements include regular class participation, bi-weekly homework assignments, a take-home exam, and a final project. Prerequisites: The course is designed for graduate and upper-level undergraduate students with a wide variety of backgrounds. The course is intended to be self-contained but students may need to do some additional work to gain fluency in core concepts. Students should have a basic knowledge of calculus, differential equations, and chemistry as well as some previous exposure to molecular biology and biochemistry. Experience with programming and numerical computation is useful but not mandatory. Laboratory exercises will use Matlab as the primary modeling and computational tool augmented by additional software as needed.

02-601 Programming for Scientists

Fall and Summer: 12 units

Provides a practical introduction to programming for students with little or no prior programming experience. Extensive programming assignments will illustrate programming concepts, languages, and tools. Programming assignments will be based on analytical tasks that might be faced by scientists and will typically include parsing, statistical analysis, simulation, and optimization. Principles of good software engineering will also be stressed. Most programming assignments will be done in the Go programming language, an industry-supported, modern programming language, the syntax of which will be covered in depth. Several other assignments will be given in other programming languages such as Python and Java to highlight the commonalities and differences between languages. No prior programming experience is assumed, and no biology background is needed. Analytical skills and mathematical maturity are required. Course not open to CS majors.

02-703 Special Topics in Bioinformatics and Computational Biology

Intermittent: 6 units

A decade ago, mass spectrometry (MS) was merely a qualitative research technique allowing the analysis of samples regarding the presence of specific biomolecules. However, as MS has turned quantitative, more sophisticated experiments can be performed, such as the recording of signal transduction kinetics and the analysis of the composition of protein complexes and organelles. This makes MS-based proteomics a powerful method to study spatiotemporal protein dynamics. The development of relative quantification approaches, which generally use ²H, ¹³C or ¹⁵N isotope labels, has especially led to an increase in quantification accuracy and set off numerous new experimental approaches to study protein regulation. In this mini-course, we will cover mass spectrometry principles, discuss classical as well as current primary literature addressing method development and quantitative analysis, and highlight state-of-the-art biological studies that employ MS. A combination of lectures, student presentations, and written exercises will establish a thorough knowledge of current bio-analytical MS approaches.

02-721 Algorithms for Computational Structural Biology

Intermittent: 12 units

Some of the most interesting and difficult challenges in computational biology and bioinformatics arise from the determination, manipulation, or exploitation of molecular structures. This course will survey these challenges and present a variety of computational methods for addressing them. Topics will include: molecular dynamics simulations, computer-aided drug design, and computer-aided protein design. The course is appropriate for both students with backgrounds in computer science and those in the life sciences.

02-740 Bioimage Informatics

Spring: 12 units

The goals of this course are to provide students with the following: the ability to use mathematical techniques such as linear algebra. Fourier theory and sampling in more advanced signal processing settings; fundamentals of multiresolution and wavelet techniques; and in-depth coverage of some bioimaging applications such as compression and denoising. Upon successful completion of this course, the student will be able to: explain the importance and use of signal representations in building more sophisticated signal processing tools, such as wavelets; think in basic time-frequency terms; describe how Fourier theory fits in a bigger picture of signal representations; use basic multirate building blocks, such as a two-channel filter bank; characterize the discrete wavelet transform and its variations; construct a time-frequency decomposition to fit a given signal; explain how these tools are used in various applications; and apply these concepts to solve a practical bioimaging problem through an independent project. Pre-requisite: 18-791, or permission of instructor. (Also known as 18-799)

Prerequisite: 18-791

Computer Science Courses**15-050 Study Abroad**

All Semesters

Students who are interested in studying abroad should first contact the Office of International Education. More information on Study Abroad is available on OIE's Study Abroad page and at the CS Undergraduate Office.

15-075 Computer Science Co-Op

Fall and Spring

This course is meant for CS undergraduate students with a full-time internship that encompasses a summer and a contiguous semester, either Spring-Summer or Summer-Fall who wish to have this recorded on their academic transcript. Units posted for this course do not count toward any requirement for the CS undergraduate degree including free elective units. This course is not available to international students; consult with the Office for International Education for more information.

15-090 Computer Science Practicum

All Semesters: 3 units

This course is for international students who are interested in working for Curricular Practical Training (CPT). Such students interested in CPT must first be authorized by the Office of International Education before being able to enroll in the Practicum course. More information on CPT is available on OIE's Foreign Student Employment page and at the CS Undergraduate Office.

15-104 Introduction to Computing for Creative Practice

Fall: 10 units

[IDEaTe portal course] An introduction to fundamental computing principles and programming techniques for creative cultural practices, with special consideration to applications in music, design and the visual arts. Intended for students with little to no prior programming experience, the course develops skills and understanding of text-based programming in a procedural style, including idioms of sequencing, selection, iteration, and recursion. Topics include data organization (arrays, files, trees), interfaces and abstraction (modular software design, using sensor data and software libraries), basic algorithms (searching and sorting), and computational principles (randomness, concurrency, complexity). Intended for students following an IDEATE concentration or minor who have not taken 15-112.

15-110 Principles of Computing

Fall: 10 units

A course in fundamental computing principles for students with minimal or no computing background. Programming constructs: sequencing, selection, iteration, and recursion. Data organization: arrays and lists. Use of abstraction in computing: data representation, computer organization, computer networks, functional decomposition, and application programming interfaces. Use of computational principles in problem-solving: divide and conquer, randomness, and concurrency. Classification of computational problems based on complexity, non-computable functions, and using heuristics to find reasonable solutions to complex problems. Social, ethical and legal issues associated with the development of new computational artifacts will also be discussed.

15-112 Fundamentals of Programming and Computer Science

All Semesters: 12 units

A technical introduction to the fundamentals of programming with an emphasis on producing clear, robust, and reasonably efficient code using top-down design, informal analysis, and effective testing and debugging. Starting from first principles, we will cover a large subset of the Python programming language, including its standard libraries and programming paradigms. We will also target numerous deployment scenarios, including standalone programs, shell scripts, and web-based applications. This course assumes no prior programming experience. Even so, it is a fast-paced and rigorous preparation for 15-122. Students seeking a more gentle introduction to computer science should consider first taking 15-110. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.

15-121 Introduction to Data Structures

Fall and Spring: 10 units

A continuation of the process of program design and analysis for students with some prior programming experience (functions, loops, and arrays, not necessarily in Java). The course reinforces object-oriented programming techniques in Java and covers data aggregates, data structures (e.g., linked lists, stacks, queues, trees, and graphs), and an introduction to the analysis of algorithms that operate on those data structures.

Prerequisite: 15-112

15-122 Principles of Imperative Computation

Fall and Spring: 10 units

For students with a basic understanding of programming (variables, expressions, loops, arrays, functions). Teaches imperative programming and methods for ensuring the correctness of programs. Students will learn the process and concepts needed to go from high-level descriptions of algorithms to correct imperative implementations, with specific application to basic data structures and algorithms. Much of the course will be conducted in a subset of C amenable to verification, with a transition to full C near the end. This course prepares students for 15-213 and 15-210. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.

Prerequisite: 15-112

Corequisites: 21-127 and 15-151

Course Website: <http://www.cs.cmu.edu/~rjsimmon/15122-s15/>**15-128 Freshman Immigration Course**

Fall: 1 unit

The Freshman Immigration Course is taken by first-semester Computer Science majors on the Pittsburgh campus. The course is designed to acquaint incoming majors with computer science at CMU. Talks range from historical perspectives in the field to descriptions of the cutting edge research being conducted in the School of Computer Science. Enrollment is limited to SCS Freshmen ONLY.

Course Website: <http://www.andrew.cmu.edu/course/15-128/>**15-129 Freshman Immigration Course II**

Fall: 3 units

This course is ONLY offered at Carnegie Mellon in Qatar. Students and instructors will solve different problems each week by searching the Web and other likely places for answers. The problems will be submitted by other faculty who will grade the quality of the answers. Students will learn strategies and techniques for finding information on the Web more efficiently; learn when to start with a search engine, a subject-oriented directory, or other tools; explore and practice using advanced search syntax for major search engines; experience specialized search engines for images, sound, multimedia, newsgroups, and discussion lists as well as subject-specific search engines; discover valuable resources to help keep you up-to-date in this fast-changing environment.

15-131 Great Practical Ideas for Computer Scientists

2 units

THIS COURSE IS OPEN TO CS FRESHMAN ONLY. Throughout your education as a Computer Scientist at Carnegie Mellon, you will take courses on programming, theoretical ideas, logic, systems, etc. As you progress, you will be expected to pick up the so-called "tools of the trade." This course is intended to help you learn what you need to know in a friendly, low-stress, high-support way. We will discuss UNIX, LaTeX, debugging and many other essential tools. Laptop required. (Laptops will be available for those without their own laptops.)

15-150 Principles of Functional Programming

Fall and Spring: 10 units

An introduction to programming based on a "functional" model of computation. The functional model is a natural generalization of algebra in which programs are formulas that describe the output of a computation in terms of its inputs—that is, as a function. But instead of being confined to real- or complex-valued functions, the functional model extends the algebraic view to a very rich class of data types, including not only aggregates built up from other types, but also functions themselves as values. This course is an introduction to programming that is focused on the central concepts of function and type. One major theme is the interplay between inductive types, which are built up incrementally; recursive functions, which compute over inductive types by decomposition; and proof by structural induction, which is used to prove the correctness and time complexity of a recursive function. Another major theme is the role of types in structuring large programs into separate modules, and the integration of imperative programming through the introduction of data types whose values may be altered during computation. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.

Prerequisites: (15-151 or 21-127) and 15-112

15-199 Special Topics: Discovering Logic

Intermittent: 3 units

This course is ONLY offered at Carnegie Mellon in Qatar. This course has the purpose of introducing first-year Computer Science students to elements of formal logic as well as to the historical context in which this discipline developed. As all subsequent courses in the CS curriculum rely on students having mastered basic logical notions and skills, it will test and enhance your preparation, thereby putting you in a better position to succeed in the program. It will also help you understand and appreciate how CS came about since Computer Science grew out of logic. The specific knowledge and skills you will learn in this course include: an enhanced ability to research topics, give presentations and write technical prose, some elementary logic, some historical depth into Computer Science, mathematics and logic itself. This course is open to Computer Science freshmen only.

15-210 Parallel and Sequential Data Structures and Algorithms

Fall and Spring: 12 units

Teaches students about how to design, analyze, and program algorithms and data structures. The course emphasizes parallel algorithms and analysis, and how sequential algorithms can be considered a special case. The course goes into more theoretical content on algorithm analysis than 15-122 and 15-150 while still including a significant programming component and covering a variety of practical applications such as problems in data analysis, graphics, text processing, and the computational sciences. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.

Prerequisites: 15-122 and 15-150

15-211 Fundamental Data Structures and Algorithms

Fall and Spring: 12 units

Fundamental programming concepts are presented together with supporting theoretical foundations and practical applications. This course emphasizes the practical application of techniques for writing and analyzing programs: data abstraction, program verification, and performance analysis. These techniques are applied in the design and analysis of fundamental algorithms and data structures. The course is currently taught in Java. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.

Prerequisites: 15-121 and 21-127

15-213 Introduction to Computer Systems

Fall and Spring: 12 units

15-213/18-213 This course provides a programmer's view of how computer systems execute programs, store information, and communicate. It enables students to become more effective programmers, especially in dealing with issues of performance, portability and robustness. It also serves as a foundation for courses on compilers, networks, operating systems, and computer architecture, where a deeper understanding of systems-level issues is required. Topics covered include: machine-level code and its generation by optimizing compilers, performance evaluation and optimization, computer arithmetic, memory organization and management, networking technology and protocols, and supporting concurrent computation. NOTE FOR GRADUATE STUDENTS: This course is not open to graduate students beginning Spring 2015. Graduate students must register for 15-513 instead.

Prerequisite: 15-122

15-214 Principles of Software Construction: Objects, Design, and Concurrency

Fall and Spring: 12 units

Software engineers today are less likely to design data structures and algorithms from scratch and more likely to build systems from library and framework components. In this course, students engage with concepts related to the construction of software systems at scale, building on their understanding of the basic building blocks of data structures, algorithms, program structures, and computer structures. The course covers technical topics in four areas: (1) concepts of design for complex systems, (2) object oriented programming, (3) static and dynamic analysis for programs, and (4) concurrent and distributed software. Student assignments involve engagement with complex software such as distributed massively multi-player game systems and frameworks for graphical user interaction.

Prerequisites: (15-121 or 15-122) and (15-151 or 21-127)

15-221 Technical Communication for Computer Scientists

All Semesters: 9 units

The course is designed for sophomore computer science majors to improve their abilities in practical, professional communications (both written and oral). It aims to help students compose clear, concise technical writings and oral presentations for multi-level audiences. Assignments include technical definitions, descriptions, instructions, process explanations, abstracts, memos, and research reports. Assignments may incorporate recent computer science research at Carnegie Mellon, projects in related technical courses, and professional case studies. Sophomores will likely find the course more useful if they have either had an internship or faculty-supervised research, including SURG projects prior to enrollment.

Prerequisite: 76-101

15-237 Special Topic: Cross-Platform Mobile Web Apps

12 units

An introduction to writing cross-platform mobile web apps. Using a tool chain based on HTML5, CSS3, JavaScript, and a variety of supporting frameworks, we will write apps that are effectively designed both for desktop and mobile browsers, and which can be converted into native apps for Android, iOS, and Windows Phone 7 devices. Additional topics will include designing user interfaces for mobile devices, accessing mobile device API's (such as accelerometer, GPS, compass, or camera), and power management issues. While this course focuses on browser-side technologies, we will briefly explore JavaScript-based server-side technologies (though students should consider 15-437 for extensive treatment of server-side topics). Note that we will not be writing native apps in Objective-C for iOS nor in Java for Android, though we may include some brief exposure to these technologies near the end of the course.

Prerequisite: 15-112

15-251 Great Theoretical Ideas in Computer Science

Fall and Spring: 12 units

This course is about how to use theoretical ideas to formulate and solve problems in computer science. It integrates mathematical material with general problem solving techniques and computer science applications. Examples are drawn from algorithms, complexity theory, game theory, probability theory, graph theory, automata theory, algebra, cryptography, and combinatorics. Assignments involve both mathematical proofs and programming. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.

Prerequisites: 15-112 and (15-151 or 21-127)

Course Website: <http://www.cs.cmu.edu/~15251>**15-294 Special Topic: Rapid Prototyping Technologies**

Intermittent: 5 units

This mini-course introduces students to rapid prototyping technologies with a focus on laser cutting and 3D printing. The course has three components: 1) A survey of rapid prototyping and additive manufacturing technologies, the maker and open source movements, and societal impacts of these technologies; 2) An introduction to the computer science behind these technologies: CAD tools, file formats, slicing algorithms; 3) Hands-on experience with SolidWorks, laser cutting, and 3D printing, culminating in student projects (e.g. artistic creations, functional objects, replicas of famous calculating machines, etc.). Please note that there will be a usage/materials fee for this course.

Prerequisites: 15-104 or 15-112

15-295 Competition Programming and Problem Solving

Fall and Spring: 5 units

Each year, Carnegie Mellon fields two teams for participation in the ACM-ICPC Regional Programming Contest. During many recent years, one of those teams has earned the right to represent Carnegie Mellon at the ACM-ICPC World Finals. This course is a vehicle for those who consistently and rigorously train in preparation for the contests to earn course credit for their effort and achievement. Preparation involves the study of algorithms, the practice of programming and debugging, the development of test sets, and the growth of team, communication, and problem solving skills. Neither the course grade nor the number of units earned are dependent on ranking in any contest. Students are not required to earn course credit to participate in practices or to compete in ACM-ICPC events.

Prerequisite: 15-122

15-300 Research and Innovation in Computer Science

Fall: 9 units

This Fall course is the first part of a two-course sequence that is designed to help prepare students to invent the future state-of-the-art in the field of computer science. Course topics will include the following: an overview of important things to know about how research and innovation works in the field of computer science; a survey of the current cutting-edge of computer science research, both here at Carnegie Mellon and elsewhere; critical thinking skills when reading research publications that disagree with each other; strategies for coping with open-ended problems; and technical communication skills for computer scientists. Students will also match up with a faculty mentor for a potential Technology Innovation Project (to be performed in the Spring), put together a detailed plan of attack for that project, and start to get up to speed (including background reading, etc.). This course can be used to satisfy the Technical Communications requirement for the CS major.

Prerequisites: 15-251 and 15-213 and 76-101 and 15-210

15-312 Foundations of Programming Languages

Spring: 12 units

This course discusses in depth many of the concepts underlying the design, definition, implementation, and use of modern programming languages. Formal approaches to defining the syntax and semantics are used to describe the fundamental concepts underlying programming languages. A variety of programming paradigms are covered such as imperative, functional, logic, and concurrent programming. In addition to the formal studies, experience with programming in the languages is used to illustrate how different design goals can lead to radically different languages and models of computation.

Prerequisites: (15-210 and 15-251) or 15-212

15-313 Foundations of Software Engineering

Fall: 12 units

Students gain exposure to the fundamentals of modern software engineering. This includes both core CS technical knowledge and the means by which this knowledge can be applied in the practical engineering of complex software. Topics related to software artifacts include design models, patterns, coding, static and dynamic analysis, testing and inspection, measurement, and software architecture and frameworks. Topics related to software process include modeling, requirements engineering, process models and evaluation, team development, and supply chain issues including outsourcing and open source. This course has a strong technical focus, and will include both written and programming assignments. Students will get experience with modern software engineering tools.

Prerequisite: 15-214

15-317 Constructive Logic

Fall: 9 units

This multidisciplinary junior-level course is designed to provide a thorough introduction to modern constructive logic, its roots in philosophy, its numerous applications in computer science, and its mathematical properties. Some of the topics to be covered are intuitionistic logic, inductive definitions, functional programming, type theory, realizability, connections between classical and constructive logic, decidable classes.

Prerequisite: 15-150

Course Website: <http://symbolaris.com/course/constlog15.html>**15-319 Cloud Computing**

Fall and Spring: 9 units

This course gives students an overview of Cloud Computing, which is the delivery of computing as a service over a network, whereby distributed resources are rented, rather than owned, by an end user as a utility. Students will study its enabling technologies, building blocks, and gain hands-on experience through projects utilizing public cloud infrastructures. Cloud computing services are widely adopted by many organizations across domains. The course will introduce the cloud and cover the topics of data centers, software stack, virtualization, software defined networks and storage, cloud storage, and programming models. We will start by discussing the cloud's motivating factors, benefits, challenges, service models, SLAs and security. We will describe several concepts behind data center design and management, which enable the economic and technological benefits of the cloud paradigm. Next, we will study how CPU, memory and I/O resources, network (SDN) and storage (SDS) are virtualized, and the key role of virtualization to enable the cloud. Subsequently, students will study cloud storage concepts like data distribution, durability, consistency and redundancy. We will discuss distributed file systems, NoSQL databases and object storage using HDFS, CephFS, HBASE, MongoDB, Cassandra, DynamoDB, S3, and Swift as case studies. Finally, students will study the MapReduce, Spark and GraphLab programming models. Students will work with Amazon Web Services and Microsoft Azure, to rent and provision compute resources and then program and deploy applications using these resources. Students will develop and evaluate scaling and load balancing solutions, work with cloud storage systems, and develop applications in several programming paradigms. 15619 students must complete an extra team project which entails designing and implementing a cost- and performance-sensitive web-service for querying big data.

Prerequisite: 15-213

15-321 Research Methods for Experimental Computer Science

Fall: 9 units

The success or failure of an experiment can turn on the details of how the experiment was performed — the experimental method. It is critical that the methodology be consistent with whatever research hypothesis is being pursued. The goal of this project-based course is to give students familiarity with and appreciation for the subtleties of a range of experimental techniques essential to high-quality empirical research. The course is based on a project that will illustrate important concepts of research methods. Example topics include user-study design and operation, data gathering, data diagnosis, experiment design and execution, signal detection, performance evaluation, error analysis, reporting results, etc. The project will explore the challenging open problem of keystroke dynamics, a biometric regime which seeks to identify/authenticate/discriminate users on the basis of their typing styles. In this context, numerous methodological issues provide the stimulus for learning how to perform empirical research from the beginning to the end of a project. Lectures will present necessary background material about the problem area and experimental methods; homework assignments and a team project will give students guided, hands-on, research and practical experience. At the end of the course, students will be acquainted with the basic issues in experimental methods, and will be able to perform independent work using the lessons learned and resources provided. Enrollment is limited to graduate students, juniors, and seniors. It will be helpful for students to have some experience with scripting languages (e.g., Perl, Python, Tcl, etc), statistically-oriented packages (e.g., R, Matlab, Weka) or other implementations of various machine-learning-type classifiers. This course can be used to satisfy the Lab requirement for the Computer Science major.

Prerequisite: 15-213

15-322 Introduction to Computer Music

Spring: 9 units

Computers are used to synthesize sound, process signals, and compose music. Personal computers have replaced studios full of sound recording and processing equipment, completing a revolution that began with recording and electronics. In this course, students will learn the fundamentals of digital audio, basic sound synthesis algorithms, and techniques for digital audio effects and processing. Students will apply their knowledge in programming assignments using a very high-level programming language for sound synthesis and composition. In a final project, students will demonstrate their mastery of tools and techniques through music composition or by the implementation of a significant sound-processing technique.

Prerequisite: 15-112

15-323 Computer Music Systems and Information Processing

Fall: 9 units

This course presents concepts and techniques for representing and manipulating discrete music information, both in real time and off line. Representations of music as explicitly timed event sequences will be introduced, and students will learn how to build efficient run-time systems for event scheduling, tempo control, and interactive processing. The MIDI protocol is used to capture real-time performance information and to generate sound. The course will also cover non-real-time processing of music data, including Markov models, style recognition, computer accompaniment, query-by-humming, and algorithmic composition. This course is independent of, and complementary to 15-322, Introduction to Computer Music, which focuses on sound synthesis and signal processing. Prerequisite: 15-122

15-346 Special Topic: Perspectives in Computer Architecture

Intermittent: 6 units

This course is ONLY offered at Carnegie Mellon in Qatar. This course will provide various perspectives in the field of computer architecture by world renowned scientists. The course will bring together basic architecture principles and designs of uniprocessor and multicore computers. First, we introduce the Von-Neuman architecture and the major hardware components of a modern computer. Students will learn how to describe an architecture design using a Hardware Description Language such as Verilog. Second, we will learn basic architectural techniques including instruction level parallelism, pipelining and cache memory. An overview of multicore architectures, specifically on how they differ from uniprocessor ones, the promises they offer, and the serious challenges they bring, will be provided. We will also discuss cache organization techniques in multicores. Students will gain insight into the designing principles that dominated past processor architectures and how they will continue to change for future processor design targeting emerging technologies such as mobile and wearable computing. The concepts delivered in the lectures will be reinforced and extended through student presentations on multiple directions in computer architecture.

Prerequisite: 15-213

15-348 Embedded Systems

Fall: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. This course covers the broad range of foundational skills that apply across all embedded computer system application areas, from thermostats to self-driving vehicles. The emphasis is at the layer where hardware meets software. Topics include microcontroller hardware, assembly language, embedded C programming, analog I/O, timers, code optimization, interrupts, and concurrency. Real world engineering practices, constraints, and example applications are integrated throughout the course. Weekly hands-on hardware and software experiences with an industry-strength automotive embedded controller are coordinated with the lecture content to reinforce core skills.

Prerequisite: 15-123

15-349 Introduction to Computer and Network Security

Fall: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. This course is meant to offer Computer Science undergraduate students in their junior or senior year a broad overview of the field of computer security. Students will learn the basic concepts in computer security including software vulnerability analysis and defense, networking and wireless security, applied cryptography, as well as ethical, legal, social and economic facets of security. Students will also learn the fundamental methodology for how to design and analyze security critical systems.

Prerequisite: 15-122

15-351 Algorithms and Advanced Data Structures

Intermittent: 12 units

The objective of this course is to study algorithms for general computational problems, with a focus on the principles used to design those algorithms. Efficient data structures will be discussed to support these algorithmic concepts. Topics include: Run time analysis, divide-and-conquer algorithms, dynamic programming algorithms, network flow algorithms, linear and integer programming, large-scale search algorithms and heuristics, efficient data storage and query, and NP-completeness. Although this course may have a few programming assignments, it is primarily not a programming course. Instead, it will focus on the design and analysis of algorithms for general classes of problems. This course is not open to CS graduate students who should consider taking 15-651 instead. THIS COURSE IS NOT OPEN TO COMPUTER SCIENCE MAJORS OR MINORS.

Prerequisites: 15-121 or 15-122

15-354 Computational Discrete Mathematics

Fall: 12 units

This course is about the computational aspects of some of the standard concepts of discrete mathematics (relations, functions, logic, graphs, algebra, automata), with emphasis on efficient algorithms. We begin with a brief introduction to computability and computational complexity. Other topics include: iteration, orbits and fixed points, order and equivalence relations, propositional logic and satisfiability testing, finite fields and shift register sequences, finite state machines, and cellular automata. Computational support for some of the material is available in the form of a Mathematica package.

Prerequisites: 15-251 or 21-228

Course Website: <http://www.cs.cmu.edu/~cdm/>**15-355 Modern Computer Algebra**

Fall: 9 units

The goal of this course is to investigate the relationship between algebra and computation. The course is designed to expose students to algorithms used for symbolic computation, as well as to the concepts from modern algebra which are applied to the development of these algorithms. This course provides a hands-on introduction to many of the most important ideas used in symbolic mathematical computation, which involves solving system of polynomial equations (via Groebner bases), analytic integration, and solving linear difference equations. Throughout the course the computer algebra system Mathematica will be used for computation.

Prerequisite: 15-251

Course Website: <http://www.andrew.cmu.edu/course/15-355/>**15-359 Probability and Computing**

Spring: 12 units

Probability theory has become indispensable in computer science. In areas such as artificial intelligence and computer science theory, probabilistic methods and ideas based on randomization are central. In other areas such as networks and systems, probability is becoming an increasingly useful framework for handling uncertainty and modeling the patterns of data that occur in complex systems. This course gives an introduction to probability as it is used in computer science theory and practice, drawing on applications and current research developments as motivation and context. Topics include combinatorial probability and random graphs, heavy tail distributions, concentration inequalities, various randomized algorithms, sampling random variables and computer simulation, and Markov chains and their many applications, from Web search engines to models of network protocols. The course will assume familiarity with 3-D calculus and linear algebra.

Prerequisites: 15-251 and 21-241 and 21-259

Course Website: <http://www.cs.cmu.edu/~harchol/15359/class.html>**15-365 Experimental Animation**

Spring: 12 units

[IDeATe course] This class will explore animation from the student's perspective with a sense of investigation toward both form and content. Topics in the class will include non-linear narrative, visual music, puppet and non-traditional materials, manipulation of motion and performance capture data, immersive environments.

Prerequisite: 15-213

15-369 Special Topics: Perceptual Computing

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. What can today's computers see, hear, and feel? This project-based course is designed to provide students exposure to the state-of-the-art in machine perception and the algorithms behind them. Student groups will design a perceptual computing project around Intel's Creative Camera or Microsoft's Kinect. Students will learn to use tools in face detection and recognition, hand and finger tracking, and speech recognition, along with algorithms to make decisions based on these input modalities.

Prerequisites: 15-122 and 21-241

15-381 Artificial Intelligence: Representation and Problem Solving

Fall: 9 units

This course is about the theory and practice of Artificial Intelligence. We will study modern techniques for computers to represent task-relevant information and make intelligent (i.e. satisficing or optimal) decisions towards the achievement of goals. The search and problem solving methods are applicable throughout a large range of industrial, civil, medical, financial, robotic, and information systems. We will investigate questions about AI systems such as: how to represent knowledge, how to effectively generate appropriate sequences of actions and how to search among alternatives to find optimal or near-optimal solutions. We will also explore how to deal with uncertainty in the world, how to learn from experience, and how to learn decision rules from data. We expect that by the end of the course students will have a thorough understanding of the algorithmic foundations of AI, how probability and AI are closely interrelated, and how automated agents learn. We also expect students to acquire a strong appreciation of the big-picture aspects of developing fully autonomous intelligent agents. Other lectures will introduce additional aspects of AI, including natural language processing, web-based search engines, industrial applications, autonomous robotics, and economic/game-theoretic decision making.

Prerequisites: 15-122 or 15-211

15-383 Introduction to Text Processing

Fall: 6 units

Text processing is a mini-course about text basic techniques of processing human language in text format. The course has theoretical and hands-on components. In the theoretical component, the course will discuss challenges in processing human languages, and review the basics of statistics and probability theory and their application to language problems. In the hands-on part, students will learn about Python programming and use it to process large volumes of text using various techniques. The processing will range from simple steps such as tokenization and part-of-speech tagging to full-fledged applications such as statistical machine translation, search and document/topic classification. The course is suited for junior and senior students in CS and IS.

Prerequisites: 15-121 or 15-122

15-385 Introduction to Computer Vision

Spring: 6 units

An introduction to the science and engineering of computer vision, i.e. the analysis of the patterns in visual images with the view to understanding the objects and processes in the world that generate them. Major topics include image formation and sensing, fourier analysis, edge and contour detection, inference of depth, shape and motion, classification, recognition, tracking, and active vision. The emphasis is on the learning of fundamental mathematical concepts and techniques and applying them to solve real vision problems. The discussion will also include comparison with human and animal vision from psychological and biological perspectives. Students will learn to think mathematically and develop skills in translating ideas and mathematical thoughts into programs to solve real vision problems.

Prerequisites: 15-122 and 21-241

15-386 Neural Computation

Spring: 9 units

Computational neuroscience is an interdisciplinary science that seeks to understand how the brain computes to achieve natural intelligence. It seeks to understand the computational principles and mechanisms of intelligent behaviors and mental abilities — such as perception, language, motor control, and learning — by building artificial systems and computational models with the same capabilities. This course explores how neurons encode and process information, adapt and learn, communicate, cooperate, compete and compute at the individual level as well as at the levels of networks and systems. It will introduce basic concepts in computational modeling, information theory, signal processing, system analysis, statistical and probabilistic inference. Concrete examples will be drawn from the visual system and the motor systems, and studied from computational, psychological and biological perspectives. Students will learn to perform computational experiments using Matlab and quantitative studies of neurons and neuronal networks.

Prerequisites: 15-112 and 21-122

15-387 Computational Perception

Fall: 9 units

In this course, we will first cover the biological and psychological foundational knowledge of biological perceptual systems, and then apply computational thinking to investigate the principles and mechanisms underlying natural perception. The course will focus on vision this year, but will also touch upon other sensory modalities. You will learn how to reason scientifically and computationally about problems and issues in perception, how to extract the essential computational properties of those abstract ideas, and finally how to convert these into explicit mathematical models and computational algorithms. Topics include perceptual representation and inference, perceptual organization, perceptual constancy, object recognition, learning and scene analysis. Prerequisites: First year college calculus, some basic knowledge of linear algebra and probability and some programming experience are desirable.

Prerequisites: 15-112 and 21-122 and 21-241

15-390 Entrepreneurship for Computer Science

Fall: 9 units

This course is designed to develop skills related to entrepreneurship and innovation for non-business undergraduate and graduate students in the School of Computer Science. The course assumes no background courses in business and is appropriate for those who are interested in bringing innovations to market either through new companies or existing companies. The course provides an overview of entrepreneurship and innovation, develops an entrepreneurial frame of mind, and provides a framework for learning the rudiments of how to generate ideas. Students come up with or are presented with potential ideas and learn how to develop these ideas into opportunities, and to explore their potential for becoming viable businesses. They learn how to do market research, to develop go-to-market strategies, value propositions and to differentiate their products or services from potential competitors. The focus is on understanding and developing strategies for approaching the key elements of the entrepreneurial process...opportunity, resources and team. The course consists of a balance of lectures, case studies and encounters with entrepreneurs, investors and business professionals. The students are exposed to financial and intellectual property issues, and encounter a real world perspective on entrepreneurship, innovation and leadership. The output of the course is a mini-business plan or venture opportunity screening document that can be developed into a business plan in a subsequent course entitled New Venture Creation or through independent study.

Prerequisites: 76-270 or 15-221

15-392 Special Topic: Secure Programming

Spring: 9 units

This course provides a detailed explanation of common programming errors in C and C++ and describes how these errors can lead to software systems that are vulnerable to exploitation. The course concentrates on security issues intrinsic to the C and C++ programming languages and associated libraries. It does not emphasize security issues involving interactions with external systems such as databases and web servers, as these are rich topics on their own. Topics to be covered include the secure and insecure use of integers, arrays, strings, dynamic memory, formatted input/output functions, and file I/O.

Prerequisite: 15-213

Course Website: <https://www.securecoding.cert.org/confluence/display/sci/15392+Secure+Programming>**15-405 Engineering Distributed Systems**

Spring: 9 units

This is a course for students with strong design and implementation skills who are likely to pursue careers as software architects and lead engineers. It may be taken by well-prepared undergraduates with excellent design and implementation skills in low-level systems programming. The course assumes a high level of proficiency in all aspects of operating system design and implementation. This course will help students prepare for leadership roles in creating and evolving the complex, large-scale computer systems that society will increasingly depend on in the future. The course will teach the organizing principles of such systems, identifying a core set of versatile techniques that are applicable across many system layers. Students will acquire the knowledge base, intellectual tools, hands-on skills and modes of thought needed to build well-engineered computer systems that withstand the test of time, growth in scale, and stresses of live use. Topics covered include: caching, prefetching, damage containment, scale reduction, hints, replication, hash-based techniques, and fragmentation reduction. A substantial project component is an integral part of the course. A high level of proficiency in systems programming is expected. If you do not have the 15-410 prerequisite you will need to get approval from the faculty.

Prerequisite: 15-410

15-410 Operating System Design and Implementation

Fall and Spring: 15 units

Operating System Design and Implementation is a rigorous hands-on introduction to the principles and practice of operating systems. The core experience is writing a small Unix-inspired OS kernel, in C with some x86 assembly language, which runs on a PC hardware simulator (and on actual PC hardware if you wish). Work is done in two-person teams, and "team programming" skills (source control, modularity, documentation) are emphasized. The size and scope of the programming assignments typically result in students significantly developing their design, implementation, and debugging abilities. Core concepts include the process model, virtual memory, threads, synchronization, and deadlock; the course also surveys higher-level OS topics including file systems, interprocess communication, networking, and security. Students, especially graduate students, who have not satisfied the prerequisite at Carnegie Mellon are strongly cautioned - to enter the class you must be able to write a storage allocator in C, use a debugger, understand 2's-complement arithmetic, and translate between C and x86 assembly language. The instructor may require you to complete a skills assessment exercise before the first week of the semester in order to remain registered in the class. Auditing: this course is usually full, and we generally receive many more requests to audit than we can accept. If you wish to audit, please have your advisor contact us before the semester begins to discuss your educational goals.

Prerequisite: 15-213

15-411 Compiler Design

Fall: 15 units

This course covers the design and implementation of compiler and run-time systems for high-level languages, and examines the interaction between language design, compiler design, and run-time organization. Topics covered include syntactic and lexical analysis, handling of user-defined types and type-checking, context analysis, code generation and optimization, and memory management and run-time organization.

Prerequisite: 15-213

Course Website: <http://symbolaris.com/course/compiler12.html>**15-412 Operating System Practicum**

Fall

The goal of this class is for students to acquire hands-on experience with operating-system code as it is developed and deployed in the real world. Groups of two to four students will select, build, install, and become familiar with an open-source operating system project; propose a significant extension or upgrade to that project; and develop a production-quality implementation meeting the coding standards of that project. Unless infeasible, the results will be submitted to the project for inclusion in the code base. Variations on this theme are possible at the discretion of the instructor. For example, it may be possible to work within the context of a non-operating-system software infrastructure project (window system, web server, or embedded network device kernel) or to extend a 15-410 student kernel. In some situations students may work alone. Group membership and unit count (9 units versus 12) will be decided by the third week of the semester. Contributing to a real-world project will involve engaging in some mixture of messy, potentially open-ended activities such as: learning a revision control system, writing a short design document, creating and updating a simple project plan, participating in an informal code review, synthesizing scattered information about hardware and software, classifying and/or reading large amounts of code written by various people over a long period of time, etc.

Prerequisite: 15-410

15-413 Software Engineering Practicum

Spring: 12 units

In this course, students will carry out a semester-long software development project for a real client. This course will be part of the Facebook Open Academy Project, providing students an opportunity to work with each other and students from other universities to make substantial contributions to external open source projects. All students registered for this course must participate in a kick-off meeting January 30th - February 1st, 2015 in Menlo Park, CA, with flight and hotel expenses to be paid by Facebook. At the kickoff meeting you will meet other members of your project team and your open source project mentor, who will provide project-specific guidance for the remainder of the semester. Students must sign up for the course and notify the instructors of their interest by November 21, 2014. A few lectures at the beginning of the course will introduce the process, tools, and documents to be used in the course, all of which will be specified by the instructors. Throughout the project, groups will be mentored through weekly team meetings with faculty. Students will make regular presentations, and will be evaluated on the code delivered, software engineering process, client satisfaction, and their contribution to the team. Students will leave the course with a firsthand understanding of the software engineering realities that drive SE practices. They will have concrete experience with these practices, and will have engaged in active reflection on this experience. They will have teamwork, process, and product skills to support immediate competency in a software engineering organization, along with a deeper understanding that prepares them to evaluate the new processes and techniques they will encounter in the workplace.

Course Website: <http://www.cs.cmu.edu/~charlie/courses/15-413/>**15-414 Bug Catching: Automated Program Verification and Testing**

Intermittent: 9 units

Many CS and ECE students will be developing software and hardware that must be ultra reliable at some point in their careers. Logical errors in such designs can be costly, even life threatening. There have already been a number of well publicized errors like the Intel Pentium floating point error and the Ariane 5 crash. In this course we will study tools for finding and preventing logical errors. Three types of tools will be studied: automated theorem proving, state exploration techniques like model checking and tools based on static program analysis. Although students will learn the theoretical basis for such tools, the emphasis will be on actually using them on real examples. This course can be used to satisfy the Logic & Languages requirement for the Computer Science major.

Prerequisites: (15-122 or 15-211) and 15-251

15-415 Database Applications

Fall: 12 units

This course covers the fundamental topics for Database Management Systems: Database System Architectural Principles (ACID properties; data abstraction; external, conceptual, and internal schemata; data independence; data definition and data manipulation languages), Data models (entity-relationship and relational data models; data structures, integrity constraints, and operations for each data model; relational query languages: SQL, algebra, calculus), Theory of database design (functional dependencies; normal forms; dependency preservation; information loss), Query Optimization (equivalence of expressions, algebraic manipulation; optimization of selections and joins), Storage Strategies (indices, B-trees, hashing), Query Processing (execution of sort, join, and aggregation operators), and Transaction Processing (recovery and concurrency control).

Prerequisites: 15-210 or (15-211 and 15-213)

15-417 HOT Compilation

Intermittent: 12 units

The course covers the implementation of compilers for higher-order, typed languages such as ML and Haskell, and gives an introduction to type-preserving compilation. Topics covered include type inference, elaboration, CPS conversion, closure conversion, garbage collection, phase splitting, and typed assembly language.

Prerequisites: 15-312 or 15-317

15-418 Parallel Computer Architecture and Programming

Spring: 12 units

The fundamental principles and engineering tradeoffs involved in designing modern parallel computers, as well as the programming techniques to effectively utilize these machines. Topics include naming shared data, synchronizing threads, and the latency and bandwidth associated with communication. Case studies on shared-memory, message-passing, data-parallel and dataflow machines will be used to illustrate these techniques and tradeoffs. Programming assignments will be performed on one or more commercial multiprocessors, and there will be a significant course project.

Prerequisite: 15-213

15-421 Information Security and Privacy

Fall: 12 units

The objective of this course is to introduce students to the technologies of Web Commerce, Security and Privacy as well as to related business, policy and usability issues. Content: Over the past 15 years, the Web has become an integral part of our daily life, whether at home or at work. This course provides students with an overview of the technologies and practices associated with Web Security, Privacy and Commerce. In the process, students will learn what it takes to design and develop successful web applications and services, reconciling security, privacy, usability and business considerations. The course is organized around two parts: Part I - Web Security & Privacy Technologies The big picture, gentle introduction to cryptography, digital signatures, key management, authentication, Internet security protocols, certificates & PKI, decentralized trust management, privacy enhancing technologies, electronic payments. Part II - Web Commerce The big picture, Internet marketing & personalization, search engines, B2B and electronic markets, P2P, Web 2.0, Mobile Commerce, social networking. Format: Lectures (including guest lectures), discussions, student presentations, and class projects. Prerequisites: 15122 or 15211 Prerequisites: 76-101 and 15-112

Course Website: <http://www.cs.cmu.edu/~sadeh/15%20421.html>**15-424 Foundations of Cyber-Physical Systems**

Intermittent: 12 units

Cyber-physical systems (CPSs) combine cyber effects (computation and/or communication) with physical effects (motion or other physical processes). Designing algorithms to control CPSs, such as those in cars, aircraft and robots, is challenging due to their tight coupling with physical behavior. At the same time, it is vital that these algorithms be correct, since we rely on CPSs for safety-critical tasks like keeping aircraft from colliding. Students in this course will understand the core principles behind CPSs, develop models and controls, identify safety specifications and critical properties of CPSs, understand abstraction and system architectures, learn how to design by invariant, reason rigorously about CPS models, verify CPS models of appropriate scale, understand the semantics of a CPS model and develop an intuition for operational effects. Students will write hybrid programs (HPs), which capture relevant dynamical aspects of CPSs in a simple programming language with a simple semantics, allowing the programmer to refer to real-valued variables representing real quantities and specify their dynamics as part of the HP.

Prerequisites: 15-122 and 21-122 and (15-251 or 18-202 or 21-241)

Course Website: <http://symbolaris.com/course/fcps14.html>**15-437 Web Application Development**

Fall and Spring: 12 units

This course will introduce concepts in programming web application servers. We will study the fundamental architectural elements of programming web sites that produce content dynamically. The primary technologies introduced will be the Django framework for Python and Java Servlets, but we will cover related topics as necessary so that students can build significant applications. Such topics include: HTTP, HTML, CSS, Javascript, XML, Design Patterns, Relational and Non-relational Databases, Object-Relation Mapping tools, Security, Web Services, Cloud Deployment, Internationalization, and Scalability and Performance Issues. Students must be comfortable programming in Java and/or Python to register for this course. Students must provide their own computer hardware for this course. Please see the Related URL above for more information.

Prerequisite: 15-214

Course Website: <http://www.jeffpinger.com/jle/web-app.html>**15-440 Distributed Systems**

Fall and Spring: 12 units

The goals of this course are twofold: First, for students to gain an understanding of the principles and techniques behind the design of distributed systems, such as locking, concurrency, scheduling, and communication across the network. Second, for students to gain practical experience designing, implementing, and debugging real distributed systems. The major themes this course will teach include scarcity, scheduling, concurrency and concurrent programming, naming, abstraction and modularity, imperfect communication and other types of failure, protection from accidental and malicious harm, optimism, and the use of instrumentation and monitoring and debugging tools in problem solving. As the creation and management of software systems is a fundamental goal of any undergraduate systems course, students will design, implement, and debug large programming projects. As a consequence, competency in both the C and Java programming languages is required.

Prerequisite: 15-213

15-441 Computer Networks

Fall and Spring: 12 units

The emphasis in this course will be on the basic performance and engineering trade-offs in the design and implementation of computer networks. To make the issues more concrete, the class includes several multi-week projects requiring significant design and implementation. The goal is for students to learn not only what computer networks are and how they work today, but also why they are designed the way they are and how they are likely to evolve in the future. We will draw examples primarily from the Internet. Topics to be covered include: network architecture, routing, congestion/flow/error control, naming and addressing, peer-to-peer and the web, internetworking, and network security.

Prerequisite: 15-213

15-449 Engineering Distributed Systems

Spring: 9 units

This is a course for students with strong design and implementation skills who are likely to pursue careers as software architects and lead engineers. It may be taken by well-prepared undergraduates with excellent design and implementation skills in low-level systems programming. The course assumes a high level of proficiency in all aspects of operating system design and implementation. This course will help students prepare for leadership roles in creating and evolving the complex, large-scale computer systems that society will increasingly depend on in the future. The course will teach the organizing principles of such systems, identifying a core set of versatile techniques that are applicable across many system layers. Students will acquire the knowledge base, intellectual tools, hands-on skills and modes of thought needed to build well-engineered computer systems that withstand the test of time, growth in scale, and stresses of live use. Topics covered include: caching, prefetching, damage containment, scale reduction, hints, replication, hash-based techniques, and fragmentation reduction. A substantial project component is an integral part of the course. A high level of proficiency in systems programming is expected. If you do not have the 15-410 prerequisite you will need to get approval from the faculty.

Prerequisite: 15-410

15-451 Algorithm Design and Analysis

Fall and Spring: 12 units

This course is about the design and analysis of algorithms. We study specific algorithms for a variety of problems, as well as general design and analysis techniques. Specific topics include searching, sorting, algorithms for graph problems, efficient data structures, lower bounds and NP-completeness. A variety of other topics may be covered at the discretion of the instructor. These include parallel algorithms, randomized algorithms, geometric algorithms, low level techniques for efficient programming, cryptography, and cryptographic protocols.

Prerequisites: 15-210 and 15-251 and 21-241

15-453 Formal Languages, Automata, and Computability

Spring: 9 units

An introduction to the fundamental ideas and models underlying computing: finite automata, regular sets, pushdown automata, context-free grammars, Turing machines, undecidability, and complexity theory.

Prerequisites: 15-251 or 21-228

15-455 Undergraduate Complexity Theory

Intermittent: 9 units

Complexity theory is the study of how much of a resource (such as time, space, parallelism, or randomness) is required to perform some of the computations that interest us the most. In a standard algorithms course, one concentrates on giving resource efficient methods to solve interesting problems. In this course, we concentrate on techniques that prove or suggest that there are no efficient methods to solve many important problems. We will develop the theory of various complexity classes, such as P, NP, co-NP, PH, #P, PSPACE, NC, AC, L, NL, UP, RP, BPP, IP, and PCP. We will study techniques to classify problems according to our available taxonomy. By developing a subtle pattern of reductions between classes we will suggest an (as yet unproven!) picture of how by using limited amounts of various resources, we limit our computational power.

Prerequisite: 15-251

15-456 Computational Geometry

Intermittent: 9 units

How do you sort points in space? What does it even mean? This course takes the ideas of a traditional algorithms course, sorting, searching, selecting, graphs, and optimization, and extends them to problems on geometric inputs. We will cover many classical geometric constructions and novel algorithmic methods. Some of the topics to be covered are convex hulls, Delaunay triangulations, graph drawing, point location, geometric medians, polytopes, configuration spaces, linear programming, and others. This course is a natural extension to 15-451, for those who want to learn about algorithmic problems in higher dimensions.

Prerequisite: 15-451

15-457 Special Topics in Theory: Advanced Algorithms

Intermittent: 12 units

Selected advanced topics in algorithms and computational theory. Topics vary from semester to semester.

Prerequisite: 15-451

15-462 Computer Graphics

Fall and Spring: 12 units

This course provides a comprehensive introduction to computer graphics modeling, animation, and rendering. Topics covered include basic image processing, geometric transformations, geometric modeling of curves and surfaces, animation, 3-D viewing, visibility algorithms, shading, and ray tracing.

Prerequisites: (21-259 and 21-240 and 15-213) or (15-213 and 21-241 and 21-259) or (18-213 and 18-202)

15-463 Computational Photography

Fall: 12 units

Computational Photography is an emerging new field created by the convergence of computer graphics, computer vision and photography. Its role is to overcome the limitations of the traditional camera by using computational techniques to produce a richer, more vivid, perhaps more perceptually meaningful representation of our visual world. The aim of this advanced undergraduate course is to study ways in which samples from the real world (images and video) can be used to generate compelling computer graphics imagery. We will learn how to acquire, represent, and render scenes from digitized photographs. Several popular image-based algorithms will be presented, with an emphasis on using these techniques to build practical systems. This hands-on emphasis will be reflected in the programming assignments, in which students will have the opportunity to acquire their own images of indoor and outdoor scenes and develop the image analysis and synthesis tools needed to render and view the scenes on the computer.

Prerequisites: 15-213 and (21-241 or 18-202)

Course Website: <http://graphics.cs.cmu.edu/courses/15-463/>**15-464 Technical Animation**

Fall: 12 units

This course introduces techniques for computer animation such as keyframing, procedural methods, motion capture, and simulation. The course also includes a brief overview of story-boarding, scene composition, lighting and sound track generation. The second half of the course will explore current research topics in computer animation such as dynamic simulation of flexible and rigid objects, automatically generated control systems, and evolution of behaviors. The course should be appropriate for graduate students in all areas and for advanced undergraduates.

Prerequisite: 15-462

15-465 Animation Art and Technology

Spring: 12 units

Animation Art and Technology is an interdisciplinary course cross-listed between Art and Computer Science. Faculty and teaching assistants from computer science and art teach the class as a team. It is a project-based course in which four to five interdisciplinary teams of students produce animations. Most of the animations have a substantive technical component and the students are challenged to consider innovation with content to be equal with the technical. The class includes basic tutorials for work in Maya leading toward more advanced applications and extensions of the software such as motion capture and algorithms for animating cloth, hair, particles, and grouping behaviors. The first class will meet in CFA room 303.

Prerequisite: 15-462

15-466 Computer Game Programming

Spring: 12 units

The goal of the course is two-fold. The first goal is to teach students some of the higher-level techniques that are necessary to implement interesting computer games. In particular, a large emphasis will be on game AI. The class will also cover such topics as game networking, scheduling of tasks in computationally intensive games, and game design. The class will also briefly cover few selected topics such as collision detection and physically-based animation that are good to know even if one is developing games using a game engine. The second goal of the class is to get students familiar with programming games on various platforms using state-of-the-art game engines. To this end, the course will have a heavy programming focus. It will have a number of projects requiring students to apply the learned material to develop games using Unity 3D game engine. The students will develop games that run on a standalone PC, games that run on an Android platform and games that work in a multi-user mode. In addition to learning the material and learning how to use game engines, the projects will provide students with portfolios of games they have developed. Such a portfolio is important in getting a job in game industry. Prerequisite is 15-462 or contact the instructor for permission.

Prerequisite: 15-462

15-486 Artificial Neural Networks

Intermittent: 12 units

Artificial neural networks combine ideas from machine learning, statistics, and pattern recognition. They draw inspiration from, and provide simplified formalizations of, theories about the workings of the brain. This course offers an introduction to neural networks for computer scientists and engineers. Prerequisites are undergraduate calculus and linear algebra, and solid programming skills. An undergraduate course in artificial intelligence or machine learning would provide helpful background but is not required. The course provides hands-on experience with a variety of neural network architectures implemented in MATLAB, and an in-depth look at problems in pattern recognition and knowledge representation. Topics covered include perceptrons, the LMS learning rule, fundamentals of pattern recognition, backpropagation learning, forward and inverse models in control theory, competitive learning, self-organizing feature maps, radial basis functions, the EM algorithm, Hopfield networks, Boltzmann machines, Helmholtz machines, and general recurrent networks.

Prerequisites: 15-212 and (18-202 or 21-241)

15-491 Special Topic: CMRoboBits: Creating Intelligent Robots

Fall: 12 units

Creating intelligent robots can be viewed as the integration of many pieces - "bits" - "RoboBits". This course will teach students such "RoboBits" for creating both single and groups of intelligent robots, with perception, cognition, and action. Students in the course work with real functional mobile robots, equipped with RGB and RGB+D cameras, different types of actuation, namely wheeled and legged robots, and computation onboard. Students learn effective vision processing algorithms for object recognition, motion modeling and planning, robot localization and planning algorithms, and multi-robot communication for shared sensing and teamwork. We will further study cognitive architectures, learning, and human-robot interaction. 15-491 is a PROJECT-BASED course, which runs in the CORAL research lab in GHC 3201. The course has three major projects with specific tasks that incrementally lead to the research and development of complete intelligent robots. The projects are decomposed in weekly tasks. The class meets twice a week, and the students have access to the lab for further work as needed. Evaluation is based on class participation, weekly progress, and project reports, presentations, and outcomes.

Prerequisite: 15-122

15-492 Special Topic: Speech Processing

Fall: 12 units

Speech Processing offers a practical and theoretical understanding of how human speech can be processed by computers. It covers speech recognition, speech synthesis and spoken dialog systems. The course involves practicals where the student will build working speech recognition systems, build their own synthetic voice and build a complete telephone spoken dialog system. This work will be based on existing toolkits. Details of algorithms, techniques and limitations of state of the art speech systems will also be presented. This course is designed for students wishing understand how to process real data for real applications, applying statistical and machine learning techniques as well as working with limitations in the technology.

Prerequisite: 15-122

Course Website: <http://www.speech.cs.cmu.edu/15-492/>

15-494 Special Topic: Cognitive Robotics

Spring; 12 units

Cognitive robotics is a new approach to robot programming based on high level primitives for perception and action. These primitives draw inspiration from ideas in cognitive science combined with state of the art robotics algorithms. Students will experiment with these primitives and help develop new ones using the Tekkotsu software framework on the Calliope robot, which includes a 5 degree-of-freedom arm with gripper, a Kinect camera on a pan/tilt mount, and Ubuntu Linux on a dual-core on-board netbook. Prior robotics experience is not necessary, but strong programming skills are required.

Prerequisite: 15-213

15-591 Independent Study in Computer Science

Fall and Spring

To be determined

15-592 Independent Study in Computer Science

Fall

to be determined

15-593 Independent Study in Computer Science

Fall

To be determined

15-594 Independent Study in Computer Science

Fall

to be determined

15-599 SCS Honors Undergraduate Research Thesis

Fall and Spring

Available only to students registered in the CS Senior Research Thesis Program.

15-610 Engineering Distributed Systems

Spring; 12 units

This is a master's level course for students with strong design and implementation skills who are likely to pursue careers as software architects and lead engineers. It may be taken by well-prepared undergraduates with excellent design and implementation skills in low-level systems programming. The course assumes a high level of proficiency in all aspects of operating system design and implementation. This course will help students prepare for leadership roles in creating and evolving the complex, large-scale computer systems that society will increasingly depend on in the future. The course will teach the organizing principles of such systems, identifying a core set of versatile techniques that are applicable across many system layers. Students will acquire the knowledge base, intellectual tools, hands-on skills and modes of thought needed to build well-engineered computer systems that withstand the test of time, growth in scale, and stresses of live use. Topics covered include: caching, prefetching, damage containment, scale reduction, hints, replication, hash-based techniques, and fragmentation reduction. A substantial project component is an integral part of the course. A high level of proficiency in systems programming is expected.

Prerequisite: 15-410

Course Website: <http://www.cs.cmu.edu/~15-610>**15-611 Compiler Design**

Fall; 15 units

This course covers the design and implementation of compiler and run-time systems for high-level languages, and examines the interaction between language design, compiler design, and run-time organization. Topics covered include syntactic and lexical analysis, handling of user-defined types and type-checking, context analysis, code generation and optimization, and memory management and run-time organization.

Prerequisites: 15213 or 15312

Course Website: <http://symbolaris.com/course/compiler12.html>**15-705 Engineering Distributed Systems**

Spring; 12 units

This course is for students with strong design and implementation skills who are likely to pursue careers as software architects and lead engineers. It may be taken by well-prepared undergraduates with excellent design and implementation skills in low-level systems programming. The course assumes a high level of proficiency in all aspects of operating system design and implementation. This course will help students prepare for leadership roles in creating and evolving the complex, large-scale computer systems that society will increasingly depend on in the future. The course will teach the organizing principles of such systems, identifying a core set of versatile techniques that are applicable across many system layers. Students will acquire the knowledge base, intellectual tools, hands-on skills and modes of thought needed to build well-engineered computer systems that withstand the test of time, growth in scale, and stresses of live use. Topics covered include: caching, prefetching, damage containment, scale reduction, hints, replication, hash-based techniques, and fragmentation reduction. A substantial project component is an integral part of the course. A high level of proficiency in systems programming is expected. Please refer to <http://www.cs.cmu.edu/~csd-grad/courseschedules14.html> this link for the most recent schedule updates.

Course Website: <http://www.cs.cmu.edu/~15-705>**15-719 Advanced Cloud Computing**

Spring; 12 units

to be determined

15-749 Engineering Distributed Systems

Fall; 12 units

Computing has changed beyond recognition in half a century, from the room-filling mainframes of the 1960s to today's smartphones and wearable devices. Networks have also changed dramatically: from the 300-baud dialup modems of the early networking era to gigabit LANs, Wi-Fi and 4G today. Who knows what changes are in store for us over the next half century? Astonishingly, in spite of this tremendous change in hardware technology over time, a small core set of techniques for building distributed systems has emerged and remained surprisingly stable and applicable across many system layers. Many flavors of these techniques exist, and they continuously evolve over time to reflect changing trade-offs in the design space. What are these core techniques, and how can we leverage them in creating distributed systems today and in the future? That is the central question addressed by this course. Students will acquire the knowledge base, intellectual tools, hands-on skills and modes of thought needed to build well-engineered distributed systems that withstand the test of time, growth in scale, and stresses of live use. Strong design and implementation skills are expected of all students. The course assumes a high level of proficiency in all aspects of operating system design and implementation. A substantial project component is an integral part of the course. Please refer to <http://www.cs.cmu.edu/~csd-grad/courseschedules14.html> this link for the most recent schedule updates.

Course Website: <http://www.cs.cmu.edu/~15-749/>**15-883 Computational Models of Neural Systems**

Intermittent; 12 units

This course is an in-depth study of information processing in real neural systems from a computer science perspective. We will examine several brain areas, such as the hippocampus and cerebellum, where processing is sufficiently well understood that it can be discussed in terms of specific representations and algorithms. We will focus primarily on computer models of these systems, after establishing the necessary anatomical, physiological, and psychophysical context. There will be some neuroscience tutorial lectures for those with no prior background in this area. Please refer to <http://www.cs.cmu.edu/~csd-grad/courseschedulef15.html> for the most recent schedule updates.

Course Website: <http://www.cs.cmu.edu/afs/cs/academic/class/15883-f13/>

Design Courses

51-101 Studio: Survey of Design

Fall; 9 units

Students will conduct activities that will help them notice design in the world, investigate how it works, and describe their thinking about design, through photography, video capture, sketching, note-taking and modeling. They will work through projects in various ways as a means of 'testing-out' and reflecting on command design approaches. This course is for undergraduate design majors only.

51-102 Design Lab

Spring: 9 units

Introduce concepts and methods to familiarize students with a range of analog and digital modes of working across products, communications, and environments. Students will use desktop modeling and comping methods to familiarize them with a range of basic materials to build confidence in using and manipulating material to represent ideas. This course is for freshman Design majors only.

Prerequisite: 51-101

51-103 Design Workshop I

Fall: 3 units

Design Workshop is a special course created for first year design students and serves as a supplement to primary studio and elective courses. In this course, students will explore design activities related to their core studio courses, receive special skills training, engage with guest lecturers, and attend field trips. Each class meets once per week.

51-104 Design Workshop II

Spring: 3 units

A recitation style course that is conducted in service of the primary design courses during the semester to provide further instruction or engage in activities that support themes and issues related to these other courses. May include work days for students to spend in studio with teaching assistants.

51-121 Visualizing

Fall: 9 units

This course introduces basic drawing and sketching techniques including figure-ground translation, 2 pt perspective construction, storyboarding for explanation, diagramming for clarification, field notation for recording through guided exercises, demonstrations, and short projects.

51-122 Collaborative Visualizing

Spring: 9 units

This course introduces frameworks of notational, exploratory and explanatory sketching using collaborative methods and exercises to cooperatively communicate design ideas. This course is for undergraduate design majors only.

Prerequisite: 51-121

51-132 Introduction to Photo Design

Spring: 4.5 units

Using a digital camera, students learn how to extend their 'seeing' with the camera, both in the world and in a shooting studio. Through shooting assignments student will understand how to: deconstruct image meaning and aesthetic choices, construction of photographic meaning and aesthetics, an understanding of color and how color delivers meaning, how a photographic studio works, proper digital photographic workflow and contemporary trends in photography. Intended for Design Majors, or permission of the instructor.

Prerequisite: 51-101

51-134 Photo Design II

Spring: 4.5 units

A continuation of Introduction to Photo Design Prerequisites: Introduction to Photo Design; 51-132

51-171 Placing

Fall: 9 units

This course will explore the context in which students study design. Using primarily photography, students compare where they are from to the bioregion of the Ohio Valley of Western Pennsylvania and the history of the steel town, Pittsburgh. Students also learn about the modern Western emergence of design as a profession and discipline, and map the edges of current design practice by interacting with local professionals.

51-172 Systems

Spring: 9 units

Explore how to understand complex phenomena by creating models of the interrelations between components. Students learn soft systems diagramming as well as the systems thinking associated with ecologies, integrative science and sociotechnical regimes. Students also learn how to see design as a way of making interventions into a leverage point in a system in order to transform how it functions elsewhere in the system.

51-173 Human Experience in Design

Intermittent: 9 units

This course introduces the central themes of design and the design professions, and the human centered focus in all aspects of design thinking and practice. We will begin by exploring the nature of having an experience, followed by the broad philosophy of design in relationship to other areas of human activity, the sciences and the arts. We will explore design through its orders of activity: first in communication and second the creation of physical objects. But design has a far greater reach into the intangible and more complex areas of human activity: interaction, systems, environments, and culture. These are the topics of inquiry for design and, unlike what the patchwork of professions would have you believe, are not fixed by boundaries. Design is enormously broad and something everybody participates in as we create the artificial world in which we live. Those who call themselves designers have greater power in shaping this world and for that reason we will end the course with a discussion of ethics. Non-Design majors are welcome.

51-201 CD Studio I: Communicating with Type

Fall: 9 units

As the first studio course in the communication design program, students explore fundamental principles of typography, where type is regarded as image, serving a range of communication goals. Projects allow students to explore form and meaning, hierarchy, legibility and readability, structure and composition, with and without images, in print and on screen. Learning to design across media, in static and dynamic formats, is critical for communication designers, as well as becoming proficient with software tools. The co-required 51-203 Computer Lab will focus on learning software relevant to projects being worked on in studio. While typography is a focused branch of communication design, this introduction to the subject opens a path for students to study all facets of communication in subsequent courses. Providing context to the subject, the course covers basic typography history, relevant typographers and their work, and technologies that have shaped typography. A guided visit to the Hunt Library's Rare Book Room provides added context. This course is for undergraduate Communication Design majors only, or permission of instructor for non-majors.

Prerequisite: 51-102

51-202 CD Studio II: Organizing Information

Spring: 9 units

In this course students participate in a range of exercises, projects, discussions, and readings that are geared towards deepening their understanding of communication design and improving their skills. Course activities require students to consider and propose ways to inform, convince, question, and engage their audiences by clarifying and organizing information. Students deconstruct existing pieces of communication design, studying how their composition, type and image usage, and hierarchy reflects the content being communicated and the order in which it is read. Working in print and digital media, students study the similarities and differences among mediums and explore methods for effectively communicating information in each area. Students analyze design examples from the perspective of the maker and the receiver(s). This facilitates discussions that focus on the role of the designer in the communication of information (Should a designer's voice be evident?) and the need for user-centered design solutions. This course is for undergraduate Communication Design majors only.

Prerequisite: 51-201

51-203 Communication Design Computer Lab

Fall: 3 units

This sophomore-level Communication Design lab introduces students to various software that designers use when creating communication pieces. Software is introduced in support of project work in 51201 CD Studio I, providing students with best practices that help them work efficiently and effectively. Software includes InDesign, Illustrator, and AfterEffects. CD majors only, or permission of the instructor.

Corequisite: 51-201

51-205 How People Work

Fall: 9 units

Exposure to holistic/emotional, cognitive, and physical factors of people, as approached by designers and interpreted by user/audience, delivered through lectures, readings, and hands-on lab activities; apply principles in team project utilizing human centered field research and design response.

51-208 Research Methods

Spring: 9 units

Learn how to select, conduct, and develop appropriate research methods for understanding and discovering contextual information and behaviors of human participants.

51-211 Generation of Form: Industrial Design I

Fall: 9 units

Generation of Form is the first studio for students in the industrial design program. Students explore product aesthetics and basic formal issues as they pertain to industrial design. This course integrates the principles of three dimensional design, drawing and prototyping as they apply to the generation of product form. Emphasis is placed on issues that dictate the form of products and their creation. Students develop basic prototyping, conceptual drawing, and presentation skills for the purpose of exploring, analyzing, refining and communicating design concepts. Required of ID students; lab fee. Due to space constraints, this course is only offered to undergraduate Industrial Design majors.

Prerequisite: 51-101

51-212 ID Studio II: Meaning of Form

Spring: 9 units

This studio course introduces students to the functional and expressive meaning of product form through creative exploration and decision-making in design. Functional product attributes include those that guide intuitive, safe, and comfortable use; expressive attributes include aesthetic, cultural, and contextual variables. Students are exposed to various methods of conceptual sketching, prototyping, and documentation to realize and communicate ideas in a process that anticipates human interpretation and response to design. Lab fee applies. This course is restricted to undergraduate Industrial Design majors only.

Prerequisite: 51-211

51-222 Decoding Place

Spring: 9 units

This course will explore ways to decode, see, think and interpret the visual language of 'place'. Through the intersection of found symbols, signs, images and color we will bring to light the function and purpose of our surroundings, and how they speak to natural and the built environment. During the course we will investigate the following question; How do we design visual systems which are understood by everyone, regardless of their language or culture but also work in harmony with natural systems? Students will work with traditional materials and tools as well as computers to understand the strengths and limitations of each, comparing their similarities and differences in the context of theoretical and applied projects. This course is for Communication Design majors only, or by permission of the instructor.

Prerequisites: 51-201 or 51-211

51-224 CD: Web Design

Spring: 9 units

This class will introduce the basics of designing and building websites, the fundamentals of HTML5 and CSS3, and responsive design approaches to assist students in creating semantically sound web pages that can be viewed across a variety of platforms, devices and browsers. The class will help students understand the constraints and advantages of working with the web as compared to traditional print media. Students will also be exposed to content management systems and topics such as responsive web design, research, and information architecture. Upon completion, students will be capable of designing, creating, launching and managing their own web sites. Your own laptop is required, with the following software installed: Adobe CS 5 or later. This course is for Communication Design Majors only.

Prerequisite: 51-201

51-225 Communications Studio I: Understanding Form & Context

Fall: 4.5 units

Giving form to messages and information using type, color, and images will be the focus of this introductory studio in Communication Design. Understanding the connection between content, intent, and form will be the goal of every project and exercise. Principles of hierarchy, chunking, sequence, clarity, and visual voice will guide work for the screen and the printed page, in dynamic and static forms.

Prerequisite: 51-122

Corequisite: 51-227

51-227 Prototyping Lab I: Communications

Fall: 4.5 units

Learn the basics of the CS suite, particularly InDesign (style sheets), Illustrator, and Photoshop; learn basics of HTML 5.0; the learning of software ideally will align with the activities conducted in the Communications Studio. This is a requirement for Design sophomores studying Communications.

Corequisite: 51-225

51-228 Communications Studio II: Designing Communications for Interactions

Spring: 9 units

Learn how to plan and structure complex information (grid systems across multiple pages/screens) that effectively communicates content to a specific audience; understand how scale, viewing distance, the form/manner in which information is presented, and phrasing, affects perception; learn the basics of systems design by developing a visual vocabulary (defining constants and variables) that is applied in various mediums

51-229 Digital Photographic Imaging

Fall: 9 units

The objective of this course is to provide students with a practical, technical and theoretical foundation in digital imaging. The primary software for this course is Adobe Photoshop, with which students will explore construction, combination, manipulation, input, and output of image as a means of narrative creation. Through project critique and other discussion, we will also consider the aesthetic and political implications of the emergence of this and other new electronic imaging technologies.

51-231 Calligraphy I

All Semesters: 9 units

Working with pure unadorned Roman letterforms, this course introduces students to the theory and practice of hand-generated letters, employing a variety of mark-making tools. This course provides an in-depth understanding of the basic principles and techniques of the art of formal writing. Rhythm, texture and composition are achieved through routine, elementary exercises using geometric forms, demanding concentration and manual discipline with the development of hand-eye coordination. The function, use, and harmonious sequencing of letterforms is taught through weekly projects. Awareness of rhythm, texture and letterform structure is achieved through routine exercises. Drills, demonstrations, discussions, individual and class critiques are on-going. Additional related topics and activities introduced in class include books: binding and design. A brief introduction to the historical development of our Western alphabet is provided through film, slides, demonstrations, with discussion of twentieth-century type designs. Students also gain exposure to letter vocabulary, paleography, monographs, words and punctuation, classical page design, publication design-past and present, and calligraphy's role in design today. Thinking with hands and eyes, the manual placement and spacing of letters practiced in this course awakens sensitivity and judgment in the designer.

51-232 Calligraphy II

All Semesters: 9 units

This course serves as a continuation and deeper investigation of topics explored in Calligraphy I, where students tackle advanced problems in calligraphy and lettering. The introduction of new hands is to be decided by the student and instructor. Prerequisites: 51231

Prerequisite: 51-231

51-236 Information Design

Fall and Spring: 9 units

This undergraduate IDEATE design course focuses on teaching a basic visual design process from start to finish. Students will work individually and in teams to gain proficiency in applying specific design methods to information design challenges at each stage of the design process.

51-239 Prototyping Lab II: Communications

Spring: 9 units

Program simple websites as a means of learning basic HTML 5.0 and CSS; prepare documents for digital and print production using Adobe InDesign, Illustrator, Acrobat

51-241 How People Work

Fall: 9 units

51241 How People Work: Human Factors (ID/CD Lab I) This course is a general introduction to the field of human-centered design and applied human factors. It centers on the understanding of physical, cognitive, and emotional human needs and desires, including methods employed to acquire this information and translate it into useful criteria for the design and evaluation of products. Lecture, discussion, lab exercises, and projects are employed. Required of all sophomore design students. Others admitted by permission of instructor only.

51-242 How Things Work: Mechanics and Electronics

Intermittent: 9 units

This course investigates the basic principles of mechanics and electronics. Through the combination of lectures, investigations, and lab experiments, students develop simplified representations of complex systems. The skills of freehand drawing, mechanical drawing and three-dimensional models are employed and developed during the project sequence. Instructor permission required for non-Design majors.

51-243 Prototyping

Fall: 4.5 units

A half-semester laboratory mini-course introducing a range of materials, methods, and workshop techniques by which designers prototype designs in three dimensions. Basic competence in shop techniques is established by bringing to realization a series of simple artifacts. Studio and model shop tools are required; lab fee. This course is for ID majors only.

Corequisite: 51-211

51-245 Products Studio I: Understanding Form & Context

Fall: 4.5 units

Learn basic design processes for understanding the scope of the project, brainstorming, defining the problem, and how interactions aid in developing solutions in relation to a human and user centered activities.

Corequisite: 51-247

51-246 Visual Communication Fundamentals

Spring: 4.5 units

Design elements are powerful tools for reaching your audience. The objective of this course is to help you understand how to use the fundamental visual tools of communication in your work, and to learn how to evaluate visual communication pieces you encounter in everyday life. Examples of design elements that we will explore are: type, color, format, images, text, pacing and sequencing. We will learn how to use these together to successfully communicate a portfolio of documented design work. This course is required for all ID sophomores.

Prerequisite: 51-211

51-247 Prototyping Lab I: Products

Fall: 4.5 units

Work in various 2D and 3D mediums to represent ideas and solutions; introduce students to digital fabrication methods and output; utilize Adobe CS suite - Illustrator, Photoshop, InDesign to communicate 2D representations.

Corequisite: 51-245

51-248 Products Studio II: Designing Products for Interactions

Spring: 9 units

Introduce student to 3D semantics, how form communicates meaning, and how to make meaningful objects through appropriate material choices and mechanical manipulation; utilize a range and combination of analog and digital tools for higher fidelity output.

51-249 Prototyping Lab II: Products

Spring: 9 units

Introduce students to high fidelity modeling techniques through a series of machines, processes, and or methods to simulate desired form, scale, and proportions

51-251 Digital Prototyping

Fall: 4.5 units

A half-semester laboratory mini-course introducing 3D modeling software. Each class meeting consists of an introduction to and demonstration of specific aspects and functions of SolidWorks software. At the end of each class session, work related to the covered topic(s) will be assigned for completion by the next class meeting. This course is a requirement for all ID majors. Instructor permission required for non-ID majors. Corequisites: 51-211

Corequisite: 51-211

51-257 Introduction to Computing for Creative Practices

Intermittent: 10 units

This course is an introduction to Java programming for designers, architects, artists and other visual thinkers, using the popular "Processing" Java toolkit for interactive graphics. Intended for students with little or no prior programming experience, the course uses interaction and visualization as a gateway for learning the traditional programming constructs and the fundamental algorithms typically found in a first course in programming. Students will become familiar with essential programming concepts (types, variables, control, user input, arrays, files, and objects) through the development of interactive games, information visualizations, and computationally-generated forms. Because of limited space, only Design majors may take this course. Students following an IDEATE concentration or minor should register for 15-104.

51-261 Communication Design Fundamentals: Design for Interactions for Communications

Fall: 9 units

A one-semester course that introduces non-majors to the field of communication design. Through studio projects, lectures, and demonstrations, students become familiar with the visual and verbal language of communication designers, the design process, and the communicative value of word and image. Macintosh proficiency required. This course is required for HCI double majors and Design minors. Section W - Qatar campus only

51-262 Communication Design Fundamentals: Design for Interactions for Communications

Spring: 9 units

A one-semester course that introduces non-majors to the field of communication design. Through studio projects, lectures, and demonstrations, students become familiar with the visual and verbal language of communication designers, the design process, and the communicative value of word and image. Macintosh proficiency required.

51-264 Industrial Design Fundamentals: Design for Interactions for Products

Spring: 9 units

A one-semester course that introduces non-majors to product development from the industrial designer's point of view. Through studio projects, lectures, and discussions, students will gain experience in visualizing a product for mass production. Case histories and the analysis of existing products will supplement hands-on experience in developing product concepts. This course is required for all ID minors.

51-265 Environments Studio I: Understanding Form & Context

Fall: 4.5 units

Learn the basic design processes for experience-driven multi-modal environments, making meaningful physical and virtual experiences through planning, structuring, and explaining/visualizing; utilize a range and combination of analog and digital tools for high fidelity output.

Corequisite: 51-267

51-266 Environments Studio I: Designing Environments for Interaction

Spring: 9 units

Introduce students to the concept of resonant environments that provide meaningful physical and virtual experiences; utilize a range and combination of analog and digital tools for high fidelity output.

51-267 Prototyping Lab I: Environments

Fall: 4.5 units

Learn CAD, Dreamweaver/HTML, and AfterEffects to build virtual models to express multi-modal aspects of integrated physical-digital environments.

Corequisite: 51-265

51-268 Environments Studio II: Designing Environments for Interaction

Spring: 9 units

Introduce students to the concept of resonant environments that provide meaningful physical and virtual experiences; utilize a range and combination of analog and digital tools for high fidelity output.

51-269 Prototyping Lab II: Environments

Spring: 9 units

Explore simple reactive and interactive programming as a means to support virtual and hybrid digital/physical environments.

51-271 How People Work

Fall: 9 units

Exposure to holistic/emotional, cognitive, and physical factors of people, as approached by designers and interpreted by user/audience, delivered through lectures, readings, and hands-on lab activities; apply principles in team project utilizing human centered field research and design response.

51-272 Cultures

Spring: 9 units

Explore the many often-unbridgeable differences between people. These differences may be not only ethnic, but also related to gender, age, class. The course will survey critical theories that are useful for warning of these kinds of differences. Students will also explore strategies for negotiating these differences, many of which require time and working at multiple levels.

51-274 Design and Social Change

Spring: 9 units

In this course we will examine the important relationships of history, culture, policies and the environment in communication design and industrial design. Conversely we will study the ways in which design can affect our culture and environment, both positively and negatively. Topics include: sustainability, universal design, system thinking and system visualization. While various cultures will be acknowledged and discussed, the major emphasis will be on Western culture. Through lectures, videos, reading and projects, students will develop their ability to incorporate historical context and consideration of potential consequences into their design process.

51-301 CD III: Type, Form, Meaning and Context

Fall: 9 units

This course develops advanced skills in typography and communication design, including the study of type and motion. Students learn to conceptualize and visualize more complex bodies of information for a variety of communicative purposes. Projects encourage students to develop a deeper understanding of the expressive potential of type and image and to develop critical and creative thinking skills with which to assess the effectiveness of their own work and that of their peers. Course objectives are to encourage an active exchange of ideas and information which allow students to develop the ability to clearly articulate their ideas and thought processes in relation to their work. This leads to a more focused method for developing and expressing ideas effectively. Instructor permission required for non-CD majors. Prerequisites: 51202

Prerequisite: 51-202

51-302 CD Studio IV: Designing with Systems

Spring: 9 units

As the final course in a sequence of typography courses for Communication Design majors, this one builds on everything learned previously. The course focuses on creating a system for dealing with large amounts of content, either self-generated or found, in print and digital platforms. The differences and similarities between traditional and new platforms of delivery provide students an understanding of where new forms of communication may be heading, given the rise in mobile devices that allow for downloading of content. Topics may include systems for the delivery of typography, images, movies, music, sound, and motion, as well as screen design and navigation. This course is required of Communication Design majors in the School of Design. Prerequisite courses include Type III, Type II, and Type I.

Prerequisites: 51301

Prerequisite: 51-301

51-311 Product Design ID III

Fall: 9 units

Students participate in a range of exercises, projects, discussions, and readings that are geared towards deepening their understanding of product design. The activities they engage in will require them to understand and consider the user as the key motivator for new and intelligent concepts that address identified problems/needs. To assist them, systematic processes will be introduced (or built upon) to guide inquiry, ideation, conceptual development, and presentation of products that are useful, usable, desirable, and more feasible than their work to date.

Prerequisite: 51-212

51-312 Products in Systems: ID IV

Spring: 9 units

This course introduces the themes of product planning and the development of products within systems and as systems. The projects are broad in scope and require students to develop products that reflect an understanding of the entire development cycle. Tools and skills for the studio and model shop are required; lab fee. Instructor permission required for non-ID majors.

Prerequisite: 51-311

51-316 Designing Spaces

Intermittent: 9 units

Stop. Look around you. Where are you and what are you doing? Are you in a lecture hall? A gallery? The check-out line at the "O"? How does the layout of the space support the activity that's supposed to happen there? How big is the space, and how is it proportioned? If you added ten feet to the ceiling height, how would it change the way it feels? Look down at your feet. What material are you standing on? Does it feel soft beneath your feet? How does it affect the sound quality of the room? Imagine it as a bright orange surface. What if the walls were rough instead of smooth-how would they catch the light differently? Does the sunlight come into the space, casting shadows? Or is the light primarily artificial, and what are the fixtures like? What, in sum, does it feel like to be in this space and what are the elements that define it? This course will present you with the opportunity to consider some of these questions, and will allow you to look at spatial issues from your perspective as a designer. The semester will be divided into sections exploring issues such as program, site, structure, material, and light, and each section will be supported by a series of exercises, lectures, and short projects. Designing Spaces should be of particular interest to those interested in pursuing exhibit design, interior design, and wayfinding design, but it may also be useful simply as a way of expanding your design framework. This course is open to junior and senior ID and CD students, and has no prerequisites

51-319 Digital Photography in the Real World

Intermittent: 4.5 units

DIGITAL PHOTOGRAPHY IN THE REAL WORLD Photographers are active observers. They look until they see what they want others to see -then they compose and click the shutter. In this course students will walk streets with their cameras. They will learn how to use their cameras to better understand what they believe is important, beautiful, and/or intriguing in the world. They will also learn how to communicate their imagery to others through screen-based and print output. Assignments range from accurately describing reality, to showing aspects of life that should be improved, to making images for purely aesthetic reasons. There are two main goals to this course: learning the fundamentals of operating a digital camera and producing digital output; and, learning to become better 'seers' in the world. Students must own a camera but no prior photographic experience is necessary.

51-321 Photographic Narrative

Intermittent: 9 units

Most photographs tell stories. We see photographs in newspapers, magazines, snapshot albums, on the web, in books, and in posters. In these contexts photographs often work with words to convey meaning, whether they are shown with captions, news stories, or just with titles. Photographs can work without words, too, to create purely visual narratives. In this course, students will make a photo narrative and determine how it will be seen. Students may make photo books, for example, or decide that their images will be seen digitally on screen. While students are making photographs, we will explore the rich traditions of photographic story-telling that range from the world-oriented work of photo-journalist W. Eugene Smith to the documentarians such as Walker Evans, Nicholas Nixon, and Alec Soth. We will look at photographers, too, who construct fictional worlds, such as Duane Michals, Cindy Sherman, and Gregory Crewdson. As students make their own narratives, we will look at the interplay between words and photographic images; how images are paced and scaled to create rhythm; how photographs are sequenced to tell stories; and other formal elements involved in creating visual narratives. 12-15 students. Prerequisite-a college level photography course.

Prerequisites: 60-141 or 51-134 or 62-141

51-322 Advanced Digital Imaging

Intermittent: 4.5 units

Building on the technical skills and methods of communicating narrative learned in Digital Imaging Advanced Digital Imaging takes communication to the next level of resolution with particular concern in artifact creation. Students explore historical and groundbreaking means of content delivery.

51-323 Communications Studio III: Designing for Complex Communication Systems

Fall: 9 units

Gain a greater understanding of how to craft communications that resonate with specific people by researching topics/audiences/contexts, by developing/iterating/testing concepts, and by investigating deeply the nuances of typographic form/image/sequencing of interactions; learn how to craft graphic form to express ideas that are not dependent on the reading of words themselves; continue to develop communication systems

Prerequisite: 51-122

51-324 Basic 3D Prototyping

Spring: 4.5 units

A half-semester laboratory mini-course introducing a range of materials, methods, and workshop techniques by which designers prototype designs in three dimensions. Basic competence in shop techniques is established by bringing to realization a series of simple artifacts. Studio and model shop tools are required; lab fee. Instructor permission required for non-CD majors. Prerequisite: 51-201

51-325 Signs/Symbols/Marks

Intermittent: 9 units

This course focuses on the formal development of pictorial signs (icons, symbols, marks, etc.) either as individual elements or as families and systems of compatible forms. Through a variety of projects, students will employ an analytical process, which includes research, observation, idea generation, development, selection, and refinement of images. We will explore the personal, social, and cultural messages that such images carry. There will be applications in two- and three-dimensional formats. Instructor permission required for non-Design majors. Prerequisite: 51-202

51-326 Photography & Family

Intermittent: 9 units

Picturing Families at Sojourner's House In this course we will partner with Sojourner's House to tell photo-based stories of the residents. Sojourner's House (SH), located in East Liberty, is a home for women and families who have faced obstacles of addiction and homelessness. Those at SH have lived through hard times. The women, some of whom are mothers, are now 'clean and sober' but before they came to SH, they were addicts who lived strained lives. As a class we will be working with women and families who now are creating positive change in their lives through Sojourner's House supportive environment. Students, working in pairs, will team with individuals or families. Through weekly sessions, students will explore how the camera can be used to tell a range of different stories, which may range from a traditional photo documentary, to a narrative that is 'directed' by a student with photographs made by Sojourner's House residents. Students may work with children to show their day-to-day life; they may work with an individual woman to tell the story of her dreams; or they may choose to work with staff at Sojourner's House to explore why someone goes into this line of work, to name a range of examples. Students will learn how to sensitively work with people who have experienced extreme difficulty while they are learning about addiction through readings and first hand accounts. While they are getting to know their subjects, students will explore the various ways to create an in-depth photo narrative. Most important, students will learn how the camera can be used to create connections and trust between people. Prerequisite: A college level photography course 12 students - sophomores to grads Familiarity with digital photography

51-327 Introduction to Web Design

Fall: 9 units

This class will introduce the basics of designing and building websites, the fundamentals of HTML5 and CSS3, and responsive design approaches to assist students in creating semantically sound web pages that can be viewed across a variety of platforms, devices and browsers. The class will help students understand the constraints and advantages of working with the web, with this course focused on technically pragmatic solutions for making websites. Students will also be exposed to content management systems and topics such as responsive web design, research, and information architecture. Upon completion, students will be capable of designing, creating, launching and managing their own web sites. Your own laptop is required, with the following software installed: Adobe CS6 or later, as well as other open-sourced software. This course is for Design Majors only, or by special permission of the instructor.

51-328 Advanced Web Design

Intermittent: 9 units

Advanced Web Design builds off of the fundamentals of Introduction to Web Design to make students more sophisticated web designers. Focusing on furthering skills beyond basic HTML5 and CSS3 and responsive design approaches, this course will also delve more deeply into web research and strategy; content development; hierarchy; design thinking; search engine optimization; and introduce students to the basics of PHP and javascript. Students will also gain a basic understanding of databases, work with content management systems, and design and develop for divergent platforms such as phones, tablets, and desktop computers. Students will develop advanced websites while mastering HTML5 and CSS3, looking at what is viable for implementation today as well as looking forward at what technology is reasonable in the near future of web design. Your own laptop is required, with the following software installed: Adobe CS6 or later, as well as other open-sourced software.

Prerequisites: 51-224 or 51-327

51-330 Communications Studio IV: Designing Communications for Social Systems

Spring: 9 units

Apply skills/knowledge learned in researching, developing, testing, refining communications to multi-faceted communication challenges that warrant the design of multiple communication pieces that span diverse mediums and function as a system; learn how to design for futuring (parts of the system yet to be determined) and for co-design where parts of the system are made for growth through contributions from audiences.

51-331 Advanced Calligraphy I

All Semesters: 9 units

This course serves a continuation of study in the discipline of calligraphy. (It meets at the same time as Calligraphy I.) Students may take one of two directions in the course. (1) Enlarging their repertoire of scripts, contemporary or traditional, for use in limited areas of work such as book or display work, or (2) Concentrating on more intensive problem solving using a limited repertoire of scripts such as Roman, Italic, Sans Serif. Prerequisites: 51232 Prerequisite: 51-232

51-332 Advanced Calligraphy II

All Semesters: 9 units

This course serves a continuation of study in the discipline of calligraphy. (It meets at the same time as Calligraphy II.) Students are encouraged to tackle advanced problems or work with the instructor to determine new directions of study. Prerequisites: 51331 Prerequisite: 51-331

51-333 Poster Design

Intermittent: 9 units

Missing Course Description - please contact the teaching department.

51-334 Photography, Community & Change

Intermittent: 9 units

In this course we will partner with Sojourner's House to tell photo-based stories of the residents. Sojourner's House (SH), located in East Liberty, is a home for women and families who have faced obstacles of addiction and homelessness. Those at SH have lived through hard times. The women, some of whom are mothers, are now 'clean and sober' but before they came to SH, they were addicts who lived strained lives. As a class we will be working with women and families who now are creating positive change in their lives through Sojourner's House supportive environment. Students, working in pairs, will team with individuals or families. Through weekly sessions with SH residents, students will explore how the camera can be used to tell a range of different stories, which may range from a traditional photo documentary, to a narrative that is 'directed' by a student with photographs made by Sojourner's House residents. In all cases, the residents at SH are going through significant change in their lives and we will see how the camera can be used to support individuals during a time of growth. Students will learn how to sensitively work with people who have experienced extreme difficulty while they are learning about addiction through readings and first hand accounts. While they are getting to know their subjects, students will explore the various ways to create an in-depth photo narrative. Most important, students will learn how the camera can be used to create connections and trust between people. Prerequisite: A college level photography course 15 students - sophomores to grads Familiarity with digital photography

51-335 Mapping and Diagramming

Fall: 9 units

This course explores the different ways in which we communicate complex information, through maps and diagrams. Students will design maps and diagrams using subject matter of their choice. Instructor permission required for non-Design majors.

51-337 Letterpress in a Digital World

Intermittent: 9 units

What value does the antiquated process of letterpress printing have in our current digital world? What can we learn from the process that was used as the primary form of reproducing the printed word for nearly 500 years? As designers and artists, we have the opportunity to re-examine an obsolete mode of commercial printing, and explore how these techniques and technologies can add to our experience, expand our repertoire, and invigorate our working process. Our goal in this course is to seek out new opportunities in expression, resulting from the harmonious merger of new and old technologies. Intended for design juniors and seniors

51-338 Documentary Photography

Intermittent: 4.5 units

Documentary Photography: the Social and Built Landscape Documentary photography explores issues, often social, humanistic and/or political, in man-made culture. This course examines the work of nineteenth, twentieth, and twenty-first century documentarians while students photographically investigate their own topics. Among the many ethical areas of a documentarian's concern, the course examines (through looking at the documentary tradition and through the student's own work) the following: the photographer's relationship to the subject; the choices involved in representing the subject; the act of selectivity in framing the subject; the reasons for making documentary photographs; the intended audience for documentary photography; and the appropriate final display of the photographs? Extensive shooting, printing, and library research. Prerequisite: A beginning photography course, or by the permission of the instructor.

51-341 How Things are Made

Fall: 9 units

This course will provide a breadth of knowledge for current manufacturing, materials, and processes encountered in the industrial design field. There will be an emphasis on actual production/manufacture methods and not rapid prototyping methods. The class will consist of various lectures, media, electronic tools, and on-site visits to enable an understanding of how mass production affects design and design decisions. Industrial Design Juniors & Seniors or permission of the instructor.

51-342 Projects in Human-Centered Design

Spring: 9 units

This course presents an opportunity to experience and understand the human centered research and design process through a self-defined project. Projects follow a common sequence of exploratory human and product research, concept generation using participatory and co-design methods, and user feedback to evaluate emerging design concepts, as they are refined. Course format includes lecture, discussion, lab exercises, interim presentations, a final presentation and thorough documentation of the research and design process. Open to all juniors and seniors in Design. All others will be waitlisted and admitted by permission of the instructor.

51-343 Products Studio III: Designing for Complex Products Systems

Fall: 9 units

Provide a framework for understanding core practices of the product design profession by placing it in relation to other disciplines and their influences on mass manufacture of goods; students will use a design process to identify problem/s, map a process in which tangible artifacts are made to learn more about the interaction between object, person, space, and context

Prerequisites: 51-243 or 51-324

51-344 Advanced Digital Prototyping

Spring: 6 units

This course is an advanced course using SolidWorks computer modeling. It is a prerequisite for Production Prototyping.

Prerequisite: 51-211

51-345 Pragmatics of Color for Non-CD Majors

Intermittent: 9 units

Pragmatics of Color for non-CD majors Throughout the course, we will explore the application of color and its' use through many different medium, products and environments. We will use a variety of source materials like pigment, colored paper, and photography. These exercises will help us to explore how the different medium affect color perception. Because color is extremely dynamic and interactive, a good deal of emphasis will be placed on your ability to iterate many variations so that comparison becomes the point of discussion and learning. Equally important, is increasing your sensitivity to the nuances of color through direct observation and experimentation. The class exercises are distinctly different in nature from one to the next; they are organized in order to build upon each other. Prerequisites: you must own a digital camera and have previous experience with Photoshop and Illustrator.

51-346 Production Prototyping

Spring: 6 units

This course is the 2nd half of Advanced Digital Prototyping, using your work in SolidWorks to produce hard models.

Prerequisite: 51-311

Corequisite: 51-344

51-347 Drawing from Nature

Intermittent: 9 units

Drawing From Nature This course is about observing and making images of things growing, crawling, flying, swimming etc. Observations will be made firsthand in the field, supported with relevant research in topic areas with the aim of deepening personal understanding of all things biological. Issue surrounding natural forms such as behavior, locomotion, adaptation, the environment and systems will also be investigated. We will work in tandem on refining our abilities in communicating what we discover through the process of drawing. A variety of visualization methods will be covered i.e. analytical drawing, visual notes, and diagramming to name a few. We will be using a variety of basic drawing and digital media to develop our work as we uncover aspects of form, structure and surface. Guest speakers will present work they have done in areas such as botany, biology, and environmental studies to name a few. A majority of the work will be done in the field and will then be developed in the studio. A final project will be assigned that will challenge you to develop a concept along with a compelling form(s) that communicates what you have uncovered about nature to a variety of audiences. This course builds on your experiences from First Year drawing and introduces several more advanced visualization methods. This course is intended for Junior and Senior Design Majors.

51-349 Visual Notation/Journaling

Intermittent: 9 units

Visual notation is the graphic equivalent of taking written notes. While the camera is a valuable and at times indispensable tool for recording what we see, the camera cannot make visible mental concepts. Nor can it discover and display underlying structures, create hierarchies, explain organizational schema or concepts that are not easily seen or understood. This course is about making visual notes in order to become fluent in your abilities to observe, record and interperate. Through daily entries in a journal you will work in several content areas i.e. mapping, natural and built environments and systems to name a few. A good portion of the work in this class will be conducted in the field using the resources available to us such as the museum, zoo and architectural sites. You will also be challenged to incorporate your notes as tools for communicating design concepts, implementing project development and presentations. The course will rely on the use of a variety of simple drawing tools and electronic media. Several visualization methods will be introduced and the work will build on the drawing experiences from First Year drawing. This course is intended for Junior and Senior Design Majors.

51-350 Products Studio IV: Designing Products for Social Systems

Spring: 9 units

Challenge students to build their own design and research process to identify and frame the scale and scope of a problem/opportunity, and place it in relation to the wider system (environment, social, cultural contexts); projects will require synthesizing a range of inputs to develop proposals for future working and living.

51-351 Drawing, Expression and Communication

Intermittent: 4.5 units

Drawing, Expression and Communication This course explores the use of drawing as a means of visualizing, communicating and expressing form, space and ideas and as such is seen as a fundamental activity used to develop visual thought in the design process. Weekly themes will be introduced, along with presentation and accompanying questions that require responses through the generation and development of work done primarily through freehand drawing. Specific conceptual and technical skills will be discussed both individually and in groups with emphasis placed on individual interpretation and exploration of the assignments with the goal of developing visual fluency. A part of the course will be spent looking at how designers have used drawing in the design process at various times through history and within a variety of contexts. Emphasis is placed on draftsmanship and more on the role drawing may play in the complex process of visual thinking and notation. Consistent with the credits allocated to this course a total of 5 hours of work, both in and outside of class, will be expected each week. A portfolio of work will be expected the last day of class. Instructor permission required for non-Design majors.

51-352 Cardboard Modeling II: Exploring expressive product behavior

Intermittent: 6 units

State-of-the-art interactive products express themselves through their screens. This behavior is mostly ?digital? in nature. In the human-computer interaction community there are many examples of interaction-styles that offer a more physical/tangible experience. In order to design products that offer such experiences new skills and tools are necessary: not only do we need to explore aspects of expressive form and interaction; we also need to explore expressive (physical) product behavior with an emphasis on sensing and actuating. While there are tools such as arduino, phidgets or gadgeteer available to do this there is little integration with the simultaneous exploration of form. This course aims to offer this integration. This course is open to Industrial Design juniors, seniors and grads ? others by permission of the instructor. Cardboard Modeling I is a prerequisite, unless approved by the instructor. Materials and tools need to be acquired in advance, a list will be provided; LAB FEE

51-353 Writing & Photography: Magazine Writing & Journalism

Intermittent: 9 units

Revealing Place: Photographers and Writers Working Together Writers and photographers have worked together throughout the 20'th and into the 21'st century to produce powerful documents. We are interested in how photographs and words describe people and places, and the dialogue that happens when words and images come together. Students will work individually and in teams, doing field research in the community as photographers and writers. Students will respond to a variety of short assignments along with a semester-long project. Course is open to Design and English juniors, seniors and grad students by instructor's permission

51-355 Experimental Sketching

Intermittent: 4.5 units

Experimental Forms of Sketching fall 2011 Advancing design drawing philosophy and application This 7 week mini course seeks to expand our experiences with interpreting forms of drawing quality within the process of sketching. This approach will explore semantics of rendering with mixed media, sensitivity of representational perspective, form building, and sequence evolution, within drawing developments that stimulate emotional connections with a viewer. Through exploring and testing variables, we will use the nature of drawing behavior processes to expand the interpretive significance of abstract idea forms. These "drawing idea forms" will be represented throughout a range of abstract levels from literal to highly figurative. Interpretations will derive from a variety of themes involving design, life, and nature and expressed on paper as objects, scenes, and story persuasions.

51-357 Stuff That's Optional: People at Play

Intermittent: 9 units

Stuff that's optional: People at play Unlike our necessary work that provides sustenance for self and dependants, our recreation is optional and chosen. Products that support recreation are, likewise, an option. Soccer balls, kayaks, daypacks, fly reels, chess sets, running shoes; for that matter, the entire recreational industry is based on election. Our lives are better off for it; play is good for us. In this studio/ project course we will investigate play as an aspect of human endeavor. There are readings, discussions, and sessions aimed at gaining an understanding of the field. We will then respond by searching out and framing design opportunities, ideate and propose, refine and test. We will make stuff as teams and individuals that help us further define what it means to be humans at play. This course is intended for Junior and Senior Design Majors.

51-359 Prototyping Tools for Embodying UX Design

Intermittent: 9 units

The course intent is to develop appropriate user experience of tools and technology for a projected time frame or context of use. The need to understand people's stories, their lives, and how they want to live determines what interfaces, products, and systems should be developed. Student teams will work together to create appropriate user interactions and experiences which are supported by the design of tools and/or technology. This integrated course will utilize rapid prototyping as the basis for the creation of these proposed tools and products. This course is intended for junior, senior, graduate level students, Non-Disclosure Agreement and other legal agreements may be part of the requirements. Proficiency in one or more of these visualization methods: freehand sketching, computer visualization in 2D graphics, motion graphics and/or 3D solid or surface modeling. By Instructor Approval if NOT in Design. Please forward statement of intent to Instructor.

51-360 Environments Studio IV: Designing Environments for Social Systems

Spring: 9 units

Develop high fidelity proposals and demonstrations of multi-modal hybridized physical-digital environments based on rich information content and principles of user experience design.

51-363 Environments Studio III: Designing for Complex Environment Systems

Fall: 9 units

Provide a framework and tools for designing for environments using experience design methods as a means to address the plurality of digital/ physical hybrid environments

51-371 Futures

Fall: 9 units

Cover different approaches to interpreting the future: from the extrapolations of trend forecasting, thought the risk assessments of scenario planning, to attempts to steering the present through backcasting. Students explore the future through utopian and dystopian fictions that are created by authors, filmmakers and themselves. Students also attempt to evaluate futures in terms of their longer term consequences.

51-372 Persuasion

Spring: 9 units

Examine written argumentation, oral presentations, artifact exhibitions, but also branding and social media. Students learn how to position their design ideas and connect them to the people and organizations that will increase their perceived value to target audiences. A focus of the course is on argument by precedent, where students build the significance of their innovations by situating them historically.

51-373 Design for Good

Intermittent: 9 units

This seminar-in-action will investigate and explore the responsibility of the designer as an agent for social change and development. We will critically examine theoretical readings, case studies, institutions and initiatives from a diversity of interdisciplinary perspectives encompassing economic, socio-cultural, political, ethical, technical and aesthetic factors. These broad survey investigations will then inform the rapid creation of design interventions, artifacts and provocations in response to our collective discoveries. Structured as one seminar and one action lab per week, students will throughout, closely document their thinking and designing in action, as a meta-lens on their own emergent role as a designer, researcher and change-maker.

51-374 Understanding Perception through Design

Intermittent: 9 units

Understanding Perception Through Design 51-374/51774 This course emphasizes audience expectations, also known as schemas, as a major influence on the artifacts we produce. For example, we read marble Corinthian columns as an entrance to a courthouse rather than to a home. The manner we use to communicate, either following or deviating from expectations, affects the way people perceive and process the information we present. Through lectures, discussions, readings, and projects, we will study the use of schemas in both print and digital mediums. We will also explore the bearing of expectations on the types of interactions and experiences we produce, answering the question: Can information become concrete and experiential versus abstract and readerly? Instructor permission required for non-Design majors. Prerequisites: 51-301 or 51-311

51-375 Meaning in Images

Intermittent: 9 units

Images abound in our culture. This course takes a critical look at many different kinds of photographic images to understand how they operate in our culture to inform, persuade, and entertain various audiences. The content for this course will be generated from looking at, thinking about and discussing issues discovered while studying well-known to lesser-known images that range from photographs used in ad campaigns, to photographs that are used in scientific representation, to snapshots in family photo albums, to photographs that are used to show social injustices, to photographs that exist in museum collections. Readings will be assigned and short writing exercises will be required throughout the semester. In addition, photography assignments will be given. Design majors will have preference. Requirement: a digital camera. 15 students, junior and senior Design Majors.

51-376 Semantics & Aesthetics

Intermittent: 9 units

The course will explore the principles of visual composition, proportioning systems and the rules of order as it relates to art, architecture and design. The class will involve extensive reading and discussion of these topics in class. Some project work will also be required but minimal to the reading. A reading list will be provided. Instructor permission required for non-Design majors.

51-377 Sensing Environments

Intermittent: 9 units

Whereas UX Design is typically described as shaping the immediate environment between a user and an object/interface, this course will instruct you in techniques, methods, and vocabularies to expand the scale of your design. Course content will give students experience integrating and shaping their current work into 2-3 other levels of scale, such as a single room, building, campus, and neighborhood. Students will walk away with an understanding of environments that will expand their range of capability, fitting for interdisciplinary application within fields such as social innovation, community development, public policy, architecture, and urban design.

51-378 History of the Book and Printing

Intermittent: 6 units

History of Books and Printing 51378 A survey of the materials and techniques used to make books covering manuscripts, calligraphy, printing, presses, type design, readers, illustrators, graphic techniques, and even e-books examined using a variety of tools: real rare books, readings, discussion, in-class exercises, essays & quizzes.

51-379 Information+Interaction+Perception

Intermittent: 9 units

As a society, we're inundated with enormous amounts of dense information on a daily basis. In fact, many of us have grown so accustomed to the abundance of information in our lives that we expect and need it to be accessible virtually anywhere and anytime. Technological advancements, which seem to develop at lightning speed, continuously provide us with tools that make it easy for us to access information quickly. However, little is being done to aid people's understanding of information that is increasing in complexity. Why? Our addiction to accessible and thorough information has caused many of us to turn a blind eye to the perceptual problems associated with its speedy delivery. In this course we will investigate contemporary visualizations of information and the bearing of their forms on the quality of communication. We will also study how peoples' perception of content, interaction with others, belief systems, and mental and physical well being can be affected by the visual communication of information. Thus, although we CAN represent information various ways we will ask how SHOULD it be designed to aid people's understanding of it. Your explorations will take the form of analyses of existing artifacts; class discussions and exercises; short, relevant readings that originate in various disciplines such as cognitive science, architecture, learning science, and design; and corresponding projects that enable you to illustrate what you're learning.

51-380 Experiential Media Design

Intermittent: 9 units

Experiential Media Design focuses on the theory, methodology and history behind the design, development and interpretation of experiential media systems. The class incorporates a multidisciplinary approach to the study of complex media systems as technological, political, economic, socio-cultural and personal experiences. Topics covered include media and communications theory, cultural studies, qualitative and quantitative methodology, design principles, human-computer-interaction, information visualization and representation, user studies and evaluation. Students will create and critique a variety of integrated media systems demonstrating technical competence, aesthetic knowledge, analytic rigor and theoretical relevance. This class is open to Junior & Senior Design Majors, and others by permission of the instructor.

51-382 Framing a Project

Intermittent: 9 units

Framing a project is a complex yet really rather simple activity. Get it right by thinking through the variables and you can set yourself up for an interesting exploration and discovery process. Get it wrong, or more likely just loosely piece it together, and you can waste time going over the same issues, and not working towards your desired goal. In this seminar course, students will design a major project of study or exploration. It is essential that they have a project idea in mind, as this will be the focus of the course. Through a series of seminars and individual tutorials we will investigate ways to integrate your area of interest academically within the context of longer-term work or research goals, as well as your current levels of expertise and interest. This course is suited to Graduate Students or advanced Senior students working towards a major project.

51-383 Topics: Conceptual Models

Intermittent: 9 units

As design problems become more complex, conceptual modeling becomes critical in design process, especially when designing for the abstract concepts such as interaction, experience, service, and systems. Creating conceptual models are often an important step for making the creative leap from user research findings to design implications, which is one of the core challenges in design process. Conceptual models are also effective tool to bring in shared understanding for different stakeholders in teams with multidisciplinary team members, user-participants, and clients. Moreover, these conceptual models often directly lead to final information products to support users to learn how to use complex systems. Conceptual Models is a full semester course that provides students with the opportunity to explore theories related to conceptual models and to improve skills in using them as a means of design. Being primarily developed for graduate and undergraduate students in Design, this course consists of two parts. The seminar part of the course will provide students with readings, examples, and in-class discussions to help them understand the nature of conceptual models. The project part of the course will provide an opportunity to apply these theories to actual projects. Students will work in individuals and teams to create conceptual models for different needs and goals in design process.

51-384 Revealing Place

Intermittent: 4.5 units

Revealing Place is a documentary photography class where students will use their cameras to explore a group, idea, and/or location and tell its story. Students will use photography as a way to engage community, document social phenomenon, and define what's happening at that moment in the history of their chosen setting.

51-385 Design for Service

Intermittent: 9 units

Technology has drastically changed society, and how we design needs to respond, too. Consider the experience of buying shoes. In past decades, before the advent of technology, customers went to a shoe store, were fitted by a clerk, and purchased shoes based on the stock in the store. Fast forward to today, where hundreds of brands and thousands of styles can be browsed online, shipped in 24 hours, and returned if less than perfect for free. The shoe purchase experience relies on system of services and products to satisfy one's needs and desires for new shoes. In this course, we will collectively define and study services and product service systems, and learn the basics of designing them. We will do this through lectures, studio projects, and verbal and written exposition. Classwork will be done individually and in teams. In some instances, we work with an external client to re-envision their core service offering.

51-387 Introduction to DeXign Futures

Intermittent: 9 units

As corporations, governmental organizations, and civil associations face accelerating change in uncertain times, increasingly they are looking to designers for new ways of thinking and acting. Designers today are engaged as thought leaders, strategists, activists, and agents of change in complex socio-technical problems throughout private, public, civil and philanthropic sectors worldwide. For designers trained to shape futures defined by uncertainty and change, these exponential times represent unprecedented creative opportunities for innovation. In this course, students learn the basic design skills necessary explore the forces that drive change in the future and learn to align innovation strategically with the trajectories of those forces.

51-388 Sharing Economies

Intermittent: 9 units

This topic course explores the nature and practice of sharing. The course is a survey of cultural theories about why and how we do and don't share and the difference design can make to systems of sharing. It explores philosophies and anthropologies of sharing, distinguishing sharing from giving, lending and exchanging. It interrogates psychologies and histories of ownership, and notions of privacy. The course also explores the range of new systems that promote sharing in the contexts of the new sociality enabled by the social media and cosmopolitan urban living. It investigates the role of politics, such as concerns about ecological sustainability, and the role of perceived autonomy and convenience. By the end of the course, you will have a more comprehensive understanding of what facilitates and constrains sharing, and so be in a better position to design systems that promote increased resource productivity. Open to Sophomore - Graduate from across the university - no prior design capacities necessary, though they will help.

51-392 Images and Communication

Intermittent: 4.5 units

No one doubts the value of photography as a means of recording life. Even if we don't think of ourselves as photographers, digital cameras make it easy to photograph our families, our trips, and aspects of our life that we want to remember. But beyond snapshots, can photography also teach us how to see? And how do they teach us about the world? And, what are the qualities inherent in photographs that make them effective as artifacts of communication? Does looking through the camera's viewfinder sensitize us to world and help us see more? Or, as some writers suggest, does the camera interfere with experiencing the world fully. This course explores seeing with the camera and the many issues that arise when one snaps the shutter. We will be looking at a range of different kinds of photographic images, understanding their contexts, and how to read them. Designers and other visual people use photographs extensively in their work. This course endeavors to make students more aware of their decisions and actions when making photographs as well as how to judge a photograph's effectiveness. The issues that we discuss using photographs, relate to other kinds of visual images, as well. We will be making photographs as we are discussing critical issues in photography that come out of readings. Students must own a digital camera but no prior photographic experience is necessary.

51-394 Communicating with Images: Beyond the Snapshot

Intermittent: 9 units

Applied Research Methods is a lecture course that explores a range of research methods from traditional behavioral research to contemporary methods in use today. The goal of the course is to understand the process that the designer employs to understand the 'say, do, make' responses of the user in order to develop appropriate solutions. We will look at a variety of methods for gathering qualitative information that inform the concept stages of the design process such as questionnaires, interviews, observations, trace measures, action research/participatory research methods. Starting out with simple exercises, we will progress to multi-method approaches for tackling more complex design problems.

51-396 Design Ethos & Action

Intermittent: 9 units

Increasingly, designers have the potential to operate as agents of change in a broad range of areas including corporate, government, non-profit, social innovation start-ups, and sustainability projects. With so much choice on the horizon, some designers may wonder, "What value do I bring to the world through design?" Values often are implicit and may vary across contexts (e.g., profit, efficiency, effectiveness, fairness, social impact, environmental impact). This course focuses on exploring and identifying the potential for positive and negative impact that design can have in the world around us.

51-398 Methodology of Visualization

Intermittent: 4.5 units

For ID and CD students who have taken First Year drawing Limit 12 students This mini-course will focus on field sketching, notation and rapid visualization in context. Over the course of 7 weeks, students will use various field excursions, exercises, and projects to develop competencies in perspective drawing, visual narratives, basic rendering, and figure drawing. The subject matter will vary, yet all lead towards generating communicative drawn artifacts. The primary project for this course will be a filled sketchbook.

51-399 Junior Independent Study

All Semesters

Guidelines for independent study in the Design office. Proposals must be approved by faculty before registration.

51-401 Senior Design Lab

Fall: 12 units

The Fall semester senior year focuses on design agility and helping students develop new ways of addressing the complexity of design problems. Through a series of three independent labs, students explore three kinds of designerly behaviors - wondering, playing, and speaking. These behaviors are not methods to be learned; they are ways of being agile as a designer that frees and empowers you to be both creative and responsive to the situations in which you are working. These labs serve as the requisite precursor to the Spring capstone project. This course is reserved for senior Design majors only.

51-403 Independent Senior Project n

Fall: 12 units

The senior year offers Design majors the opportunity to explore a variety of advanced topics through project-oriented courses. These project courses typically require an integration of skills and knowledge gained throughout the entire design program. Senior projects are often funded by outside companies or organizations, providing real world clients. This project highlights the role that visual interface designers play in the multi-disciplinary attempt to bridge the gap between functionality and usability and to introduce students to some of the unique challenges of designing within the realm of a digital, interactive medium.

51-404 Senior Project

Spring: 12 units

The senior year offers Design majors the opportunity to explore a variety of advanced topics through project-oriented courses. These project courses typically require an integration of skills and knowledge gained throughout the entire design program. Senior projects are often funded by outside companies or organizations, providing real world clients.

51-405 Senior Project: Communication Design

Fall: 12 units

The senior year offers Design majors the opportunity to explore a variety of advanced topics through project-oriented courses. These project courses typically require an integration of skills and knowledge gained throughout the entire design program. Senior projects are often funded by outside companies or organizations, providing real world clients. This project varies from one semester to the next, providing various opportunities in areas such as exhibit design, branding, and web design.

51-406 Senior Project II

Spring: 12 units

The senior year offers Design majors the opportunity to explore a variety of advanced topics through project-oriented courses. These project courses typically require an integration of skills and knowledge gained throughout the entire design program. Senior projects are often funded by outside companies or organizations, providing real world clients.

51-407 Senior Project: Social Impact by Design

Fall: 12 units

The senior year offers Design majors the opportunity to explore a variety of advanced topics through project-oriented courses. These project courses typically require an integration of skills and knowledge gained throughout the entire design program. Senior projects are often funded by outside companies or organizations, providing real world clients. This project focuses on new product development.

51-408 Senior Project: Environmental Design

Spring: 12 units

This is the spring offering of 51-409

51-409 Senior Project: Environmental Design

Fall: 12 units

The senior year offers Design majors the opportunity to explore a variety of advanced topics through project-oriented courses. These project courses typically require an integration of skills and knowledge gained throughout the entire design program. Senior projects are often funded by outside companies or organizations, providing real world clients. This project involves the design of a space, both indoors and outdoors, navigation of the space, and use of the space. Projects could include signage, exhibit design, navigation and wayfinding, furnishings within a space, or even park design.

51-414 Senior Project III (IPD)

Spring: 12 units

This course provides an integrated perspective on the many processes by which new products are designed, manufactured, and marketed. Under the direction of faculty from Design, Engineering, and Industrial Administration, students will work together in interdisciplinary groups on the development of real products. In addition to the product development project, the course includes lectures on innovation strategy, opportunity identification, designing products, object representation and manufacturability rules, computer-assisted design and prototyping, concept testing and protocol analysis, redesign issues, market testing, manufacturing and production, and product introduction and management. Open to graduate and senior-level engineering students, industrial administration students, and design students.

51-421 Basic Interaction Design

Fall: 9 units

This course highlights the role that visual interface designers play in the multi-disciplinary attempt to bridge the gap between functionality and usability and to introduce students to some of the unique challenges of designing within the realm of a digital, interactive medium.

51-422 Interaction Design Studio

Spring: 9 units

Intended for HCI double majors, this is the spring offering of 51-421 Introduction to visual interface design. This course highlights the role that visual interface designers play in the multi-disciplinary attempt to bridge the gap between functionality and usability and to introduce students to some of the unique challenges of designing within the realm of a digital, interactive medium.

51-423 Pieces 2.0: Social Innovation: Desis Lab

Intermittent: 9 units

In this class, students will identify a social problem and take a holistic design approach to solving it. They will design a product/product line—anything from a set of tools to help older adults lead a more active lifestyle, to re-envisioned collateral for the Lupus Foundation Pennsylvania. After or in tandem with the creation of this product, the student will construct an image, which will entail print media, a Web presence, packaging, and photography. By creating the product and its "marketing" effort from top-to-bottom, the student will gain a diverse set of skills in design as well as a richer understanding of the product. In the end, all the pieces will come together to create a well-refined image.

51-424 Web Portfolio

Intermittent: 4.5 units

This course will provide an opportunity for students to design and code their online portfolio. The course covers basic elements of Web design along with the foundations of HTML, CSS, Javascript and Flash as components of the design process. Prior experience with HTML is encouraged but tutorials will be provided if necessary. This is not an Actionscript programming course.

51-425 Beginning Book Arts Lab

Fall and Spring: 6 units

Beginning Book Arts Lab Class. 6units. (This class is a prerequisite for the Advanced Book Arts Workshop Lab Class). This is a class of basic issues regarding hand bookbinding and letterpress printing. It's purpose is to develop a basic structural sense of book forms, of flat format work and of three dimensional forms. Learning hand craft techniques, developing hand skills and the sensitivity to materials are also a goal. Binding projects assigned will target the unique nature of papers, fabrics and archival card-boards. Structural procedures and techniques will be identified with each assigned binding project. The binding projects will be: A hardcover for a paper back book, a single signature book, a multi-signature book with flat spine, and a box construction. The box project is designed and crafted to contain a small letterpress printed class edition, either in book form, or as a set of un-bound pages. The letterpress component teaches the standard issues, unique to the relief process, in press work, handset procedure of cast metal type, page form spacing, lock-up of pages in press, proofing, and production printing. Each semester a small class edition project of text content and image, in two-color registration, is designed, hand set and printed. Image generation can be by hand cut block, assembled type-high forms, or digital process to polymer plate. This class is not to be repeated.

51-426 Beginning Book Arts Lab

Spring: 6 units

Beginning Book Arts Lab Class. 6units. (This class is a prerequisite for the Advanced Book Arts Workshop Lab Class). This is a class of basic issues regarding hand bookbinding and letterpress printing. It's purpose is to develop a basic structural sense of book forms, of flat format work and of three dimensional forms. Learning hand craft techniques, developing hand skills and the sensitivity to materials are also a goal. Binding projects assigned will target the unique nature of papers, fabrics and archival card-boards. Structural procedures and techniques will be identified with each assigned binding project. The binding projects will be: A hardcover for a paper back book, a single signature book, a multi-signature book with flat spine, and a box construction. The box project is designed and crafted to contain a small letterpress printed class edition, either in book form, or as a set of un-bound pages. The letterpress component teaches the standard issues, unique to the relief process, in press work, handset procedure of cast metal type, page form spacing, lock-up of pages in press, proofing, and production printing. Each semester a small class edition project of text content and image, in two-color registration, is designed, hand set and printed. Image generation can be by hand cut block, assembled type-high forms, or digital process to polymer plate. This class is not to be repeated.

51-427 Advanced Book Arts Workshop

Intermittent: 9 units

Students will be required to plan and design projects that relate to binding, or digital printing, or letterpress printing, or hand-setting of cast metal type. Projects utilizing a combination of all processes can be planned as well. Experimental work, or Artists' Books are also encouraged. In this class structure students will be able to plan and design projects that are complete books, with printed content, or with out content. Other flat structures, and three dimensional containers are examples of general forms that will be categorized as binding work. Students who wish to enroll in this course must have already taken Beginning Book Arts, and must also speak to the instructor directly about project ideas. Emphasis for binding is working independently with a greater level of hand craft and a sensitivity to materials. Emphasis for letterpress printing is to learn in depth, and master, the general mechanical process for doing press work. Emphasis for hand typesetting is on gaining an understanding of the system of cast metal type, and to develop a sensitivity to typographic principles. Instruction will be given on an individual basis through consultation at strategic times throughout the semester. Project evaluation will be based on the success of the project work compared to each student's written project proposal at the start of the semester. The Advanced Workshop in Book Arts can be repeated. For more complex project work this class can be continued for the following semester.

Prerequisites: 51-425 or 51-426

51-428 Time, Motion and Communication

Intermittent: 9 units

This course focuses on designing and presenting time-based messages on screen. The differences between paper-based and screen-based communication are discussed and become departure points for projects. Working with word, image, sound, and motion — in Adobe AfterEffects — students develop responses to a variety of project briefs. Brief histories of animation, experimental films, and title sequences, as well as experimental music provide conceptual models to our discussions. An attitude of exploration is stressed, with an emphasis on visual voice, performance, and communication. Content will include personal messages and timely information. Proficiency with AfterEffects is a firm requirement. Preference will be given to junior and senior Design students.

51-431 Revealing Place

Intermittent: 9 units

Revealing Place is a documentary photography class where students will use their cameras to explore a group, idea, and/or location and tell its story. Students will use photography as a way to engage community, document social phenomenon, and define what's happening at that moment in the history of their chosen setting.

51-433 Advanced Interaction

Intermittent: 9 units

An interface is the link between a user and a product that communicates how a product will be used and creates an experience for the people who will use it. Interaction design is the process of creating and defining product behavior, encompassing both usability and aesthetic dimensions of an artifact, service, or environment. In this course, we will explore issues that pertain to the design of interfaces that activate vision, hearing and touch, with a focus on a variety of design principles, information hierarchy and navigation, multi-modal information presentation, user-product interactions, and how these elements become part of a larger design process. Students will develop a process for creating interface designs that can be reapplied in future contexts.

Prerequisite: 51-421

51-434 Experimental Form

Intermittent: 9 units

The Experimental Form Studio looks broadly at the discipline of industrial design with an emphasis on creating new paradigms for interactive objects. This course encourages an exploratory study of physical objects and artifacts and provides a creative and intellectual forum to re-imagine our relationship with objects. Each independently-themed project presents opportunities to consider embedded mechanics & technology, objects as interactive media, and experience-driven design. Experimental Form, at its most basic, is a process that blends play and inquiry in an open-ended way finding the unexpected through tinkering and trying something you don't quite know how to do, guided by imagination and curiosity. In this course, there are no instructions, no failures, no prescribed right or wrong ways of doing something. In this sense, Experimental Form complements the core ID Studio sequence by providing a playground for intellectual discourse, experimental trial and error, and refining individual processes for designing. This is your sandbox. Prerequisites: Junior standing in industrial design or MPD. Junior level communication design, MTID, MDes with instructor permission.

51-435 Presentation & Pitch Design

Intermittent: 4.5 units

Presentation & Pitch Design: The premise of the course is to provide design students with the fundamental tools to effectively present and pitch their designs. The foundation of the course is best explained by Dick Buchanan he states, "The designer, instead of simply making an object or thing, is actually creating a persuasive argument that comes to life whenever a user considers or uses a product as a means to some end." (Buchanan, R. 1985) I am looking to enter into a dialogue with undergraduate and graduate design students based on the notion of creating a "persuasive argument" to their design presentations. More importantly, I am looking to facilitate skill development using narratives as a medium for design students to present and pitch the intent of their designs based on five core principles. intentional positioning (empathize with your audience) restraint in preparation (concise structure) simplicity in design (visual congruence with design artifact) clarity in rhetoric (know your message) naturalness in delivery (be yourself) Upon completion of this class, students will have mastery in the Five Core Principles mentioned. They will be able to: Identify and cater to their audience's needs Empathize with their audience and adjust accordingly Craft a narrative that captures their design intention(s) Visually compliment their design in their presentation Clearly develop their message (pitch) Develop and present in their own style

51-439 Design for Service Studio

Intermittent: 9 units

Services constitute more than 79.2% of the US economy. The service sector has been increasing substantially while the commodities and manufacturing sectors have experienced a steep decline. Yet, service providers have historically under-utilized design in its business strategy and development. During this project course, intended to work in conjunction with Designing for Service Seminar, we will extend the idea of design as more than aesthetics and provide the opportunity for students to practice embodying its perspective and process, mapping design theory to project process. Students will spend the semester in teams, working with the Pittsburgh Post-Gazette to deeply understand their users and stakeholder's experiences, needs, and desires. We will explore the role of journalism and news in society, the volatile sector as a whole, and the challenges facing newspapers in America. The human-centered design approach will employ ethnographic research methods, allowing for teams to uncover insights and observations about patterns. Students will in turn learn to synthesize these findings into appropriate models, prototype concepts, and look for opportunities. The design solutions are intended to inform elements of the paper's competitiveness, creativity, development and future service innovations. The final deliverable will be refined solutions as illustrated in a presentation and process document.

51-441 Foundation of BME Design

Fall: 6 units

This course focuses on the Product Development scope and framing of a new medical device. Students will work together in an interdisciplinary team with Biomedical Engineering students to identify medical professional or patient needs through behavioral research and participatory research methods. This course deliverable requires the team to propose the problem space and develop a design brief and plan for the following Spring semester to implement. Prerequisite: Junior level design or higher with studio training. Solid modeling or surface modeling recommended.

51-442 BME Design Project

Spring: 9 units

This course is the second in sequence of prototyping and testing a proposed medical device product. The course consists of modules for the development of a project plan, background research, hazard analysis, setting product specifications based on user requirements, detailed design and analysis, prototype development and final documentation and presentation. All products developed will respond to the needs of appropriate market segments; resulting products will be deemed safe, effective, useful, usable and desirable by those segments. Students will produce a form model, functional prototype, marketing plan, and manufacturing plan of their product. Prerequisite: 51-441 (3 units, Fall) Foundations of Biomedical Engineering Design (or permission of the instructor). Junior level design or higher with studio training. Solid modeling or surface modeling recommended.

51-451 Fundamentals of Joinery & Furniture Design

Fall: 9 units

Intensive introduction to traditional joinery techniques and the properties of wood through the use of textbook studies and lab experiments. Emphasis placed on how these techniques and properties influence design decisions. Students will learn how to set up, sharpen and use traditional hand powered tools. This acquired knowledge will be applied in the design and realization of a piece of wooden furniture. Limited enrollment. Lab fee and material purchases required. Prerequisite: 51-243

51-452 Furniture Design II

Spring: 9 units

A continuation of 51-451, this course explores a much broader range of issues related to furniture design. Students will identify and define in a proposal the area of furniture design they intend to investigate and then produce one or more furniture pieces developed from their findings. Materials and processes applied to the project are limited only by the resources the student can bring to bear. Assigned readings and a series of in-class discussions will focus on the influence of workmanship in design, and on how the behavior of the user is influenced by the form or esthetic language of the artifact. Lab fee & material purchases required. Prerequisite: 51-451

51-453 Applied User Research

4.5 units

This course is an opportunity for students to study how user research applies to concrete design projects in an organizational context. We will study three different design projects that pursue a human-centered design approach: The Domestic Mail Manual (DMM) Transformation Project by the United States Postal Service, the Australian Taxation Project by the Australian Tax Office, and the Income Tax Form Redesign by the Internal Revenue Service of the United States. Students will trace the role of user research in each case. The class will take the format of a seminar with lectures, presentations and readings. Together with actual samples from the three case studies, they will provide a background for rich discussions. Students will walk away with three key insights into applied user research: They will understand how user research applies to a complex system, such as an organization. Simultaneously, students will gain an understanding of the opportunities and the potential pitfalls that arise when co-designing with a client. Finally, By studying the design process and the artifacts that were developed by these three projects, the contribution of user research in designing interactions of individuals with organizations, the effect of user research on an organization and the role of user research organizational change will become evident. Open to graduate and advanced undergraduate students in design. Because of the nature of the projects and the organizations involved, this course may also be of interest to students with a background in organizational behavior, management and public policy.

51-455 DeXign the Future: Human Centered Innovation for Exponential Times

Intermittent: 9 units

DEXIGN THE FUTURE: Human Centered Innovation for Exponential Times As corporations, governmental organizations, and civil associations face accelerating change in uncertain times, increasingly they are looking to designers for new ways of thinking and acting. Designers today are engaged as thought leaders, strategists, activists, and agents of change in complex socio-technical problems throughout private, public, civil and philanthropic sectors worldwide. For designers trained to shape futures defined by uncertainty and change, these exponential times represent unprecedented creative opportunities for innovation. In this course, students explore methods and tools for design in exponential times to shape uncertain futures. Students will explore the forces that drive change in the future (i.e., social, economic, political, environmental, technological), and learn to align innovation strategically with the trajectories of those forces. The design project that drives everything else is the future of mega-metropolitan regions, the hubs of innovation where 70% of people in the world and 75% of Americans will live in 2050. In the semester long project, students create scenarios for Life 2050 in Metro 3.0, using Pittsburgh as a locus and focusing on a project within urban systems such as Sustainable Production & Consumption, Lifelong Learning, Human Development and Resilient Community.

51-471 Practicing Design

Fall: 9 units

This is a lecture course covering all aspects of design practice. Students learn to formulate a plan for professional practice, market creative services, manage projects, and understand the legal and ethical issues associated with design practice. This course will also address the changing role of the design professions. Visiting professionals, case studies, and supplementary readings provide resources for class discussion. This course is required for all senior design majors.

51-472 Globalization and Design

Intermittent: 4.5 units

Designers are often required to plan products for markets around the world. Diversity of cultural value plays a central role in user experience and product development in the global context. This mini course is a seminar that explores the topic of culture. The first part of the course will provide students with terminology, perspectives, concepts, and knowledge based on discussions of selected readings from the classic and contemporary literature as well as diverse examples from the field. The second part of the course will examine how these theories relate to design research and practice. Individual and group assignments will help students relate the concepts to the practice of design.

51-478 Design Fiction & Imaginary Futures

Intermittent: 9 units

This praxis-based course will actively engage futures research through the integration of findings from critical readings, ethnographic research, mediated storytelling and hybrid prototyping. Using techniques of inversion, defamiliarization, uncertainty scenarios, everyday practice and good old-fashioned humor, we will create objects, systems and experiences that stimulate conversation, debate and understanding. The course seeks to produce a diversity of 'what will?' and 'what if?' cultural provocations that deeply examine possible, unwanted and seductive futures. This course is open to Junior and Senior Design majors, or by permission of the instructor.

51-479 Design for Improved Understanding of Health Information

Intermittent: 9 units

During the course students will use a design framework and proven methodologies to create health communications that aid low health literate individuals to better understand their role in the system of care, evaluate where, when and how to access care and communicate with peers and experts when they need help. Students will work closely with the Regional Health Literacy Coalition and various social institutions to insure relevance, context, and access.

51-480 Capstone Design Project: Service Design

Spring: 12 units

Learn how to work independently, applying skills/knowledge in Products, Communications, Environments to the research/definition/development/testing of a project that focuses on the design of a service that warrants investigation; deepen understanding of service design principles and how they are put into practice.

51-481 Design Research Studio: Service Design

Fall: 12 units

Learn how to work with a group of designers, applying skills/knowledge in Products, Communications, Environments to the research/definition/development/testing of a project that focuses on the design of a service that warrants investigation; gain an understanding of service design principles and how they are put into practice; learn how to manage a semester-long project, preferably working with a local client.

51-483 Debating the Roles & Responsibilities of the Designer

Intermittent: 9 units

Designers are expected to play a role in creating aspirational lifestyles through products and services, and informing and influencing human behavior on small and large scales. However what impact does or should the designer have on our lives, our society, and culture? Through readings, discussions, and team activity, students will construct pro and con arguments and debate the role and responsibility of the designer in a critical and fun way.

51-488 Design, Management and Organizational Change

Intermittent: 9 units

Design, Management, and Organizational Behavior 51-488/51-788 The goal of this course is to help Design students better understand how organizations affect the practice of design and, in turn, how the practice of design and affect organizational life. Topics covered will include the history and theory of management, some of the current practices of management that have direct bearing on design (such as strategic planning), and some of the central concepts of organizational theory that will help students learn to interpret and work within organizations. Pre-requisites: this course is intended primarily for design graduate students, with a few seats reserved for undergraduate Design majors. Non-Design majors must obtain the instructor's permission to register for this course.

51-490 Capstone Design Project: Social Innovation

Spring: 12 units

Learn how to work independently, applying skills/knowledge in Products, Communications, Environments to the research/definition/development/testing of a project that focuses on the design of social innovation that warrants investigation; deepen understanding of social innovation design principles and how they are put into practice.

51-491 Design Research Studio: Design for Social Innovation

Fall: 12 units

Learn how to work with a group of designers, applying skills/knowledge in Products, Communications, Environments to the research/definition/development/testing of a project that focuses on design of a social innovation that warrants investigation; gain an understanding of social innovation design principles and how they are put into practice; learn how to manage a semester-long project, preferably working with a local client.

51-499 Senior Independent Study

All Semesters

Guidelines for independent study in the Design Office. Proposals must be approved by faculty before pre-registration.

51-880 Experiential Media Design

Intermittent: 12 units

Experiential Media Design focuses on the theory, methodology and history behind the design, development and interpretation of experiential media systems. The class incorporates a multidisciplinary approach to the study of complex media systems as technological, political, economic, socio-cultural and personal experiences. Topics covered include media and communications theory, cultural studies, qualitative and quantitative methodology, design principles, human-computer-interaction, information visualization and representation, user studies and evaluation. Students will create and critique a variety of integrated media systems demonstrating technical competence, aesthetic knowledge, analytic rigor and theoretical relevance

Dietrich College Information Systems Courses

67-100 Information Systems Freshman Workshop

Fall: 1 unit

This class provides an overview of the Information Systems Program for freshman students. The Program's academic advisor facilitates discussion of the field of IS, the curriculum, and careers, as well as co-curricular experiences such as internships and study abroad. Guest lecturers include the IS faculty, IS alumni, the IS career consultant, and various campus representatives. Discussions will include students' progress in their first semester, as well as guidance in course planning, for creating their Spring semester schedule of classes, and their overall four-year plan.

67-101 Concepts of Information Systems

Spring: 6 units

This course provides an overview of the core concepts of information systems, and the impact of IS on the broader world. To this end, students will be exposed to the key concepts of people, process, and technology in information systems through lecture, case study, and project experience. Time in lecture will discuss topics such as the history of IS, the economics of information, as well as the key organizational and social issues. The class will study in detail the development of an IS project, and review some of the skills necessary for successful implementation of information systems. Finally, students will put these concepts into practice by working in small teams on an innovation project. This course is for Information Systems Freshmen only.

67-102 Concepts of Information Systems

Fall: 9 units

This course is an introduction to the world of Information Systems (IS). It introduces the core concepts of IS and its importance in the modern world around us. The course provides a general overview on the implications of information systems on organizations, by describing what an information system is; presenting some IS applications and discussing the implications of information systems on social and human aspects. The course also provides an initiation to essential information systems skills such as team work and project management.

67-103 Fundamentals of Web Design

Spring: 3 units

This course utilizes a hands-on approach to teaching the fundamentals of HTML5, CSS3 and Javascript (using jQuery). Each class starts with a brief presentation on a particular aspect of web design and then students use the remaining time to work through a technical challenge under the guidance of faculty and teaching assistants. This course is for Information Systems Freshmen only.

67-205 Principles of Front End Engineering

Spring: 6 units

Front-End Engineers create code that make websites interactive and exciting. That code is interpreted by a web browser or other client, using HTML, CSS, JavaScript, XML/XSLT, and Flash/Flex and differ from application development performed by Back-End Engineers. Freshman or Sophomore status major Information Systems, Computer Science or Business. Prerequisites or co-requisite: 15110
Corequisite: 15-110

67-211 Introduction to Business Systems Programming

Fall and Spring: 6 units

This course is an introduction to the COBOL programming language. In addition to the basic syntax of the language, the course presents several information systems applications and discusses their solution in COBOL. COBOL is the most widely used language in the business community. New versions of COBOL for Unix and PC's have enhanced its status in the programming world. This class is a combination of lecture, readings, and programming. Students leave the course with an understanding of the COBOL syntax and the data file usage. The instruction emphasizes the importance of design and maintenance as well as coding in developing business applications.

67-250 The Information Systems Milieux

Spring: 9 units

Information systems (IS) are changing work practices, reshaping organizations, transforming cultures, and giving new meaning to the ways we see the world. This course is designed to help students understand the role of IS in modern society and the means by which these systems are created. It provides not only a framework for understanding information and information systems, but also a language to identify their dynamic complexities and inter-dependencies. Topics include: current trends in IS, structured approaches to the creation of IS, corporate IS competitive advantage, business process improvements/re-engineering, eCommerce and the digital economy, knowledge management, decisions support systems, and the implications of IS for people, organizations and society. Classes will use a combination of lectures, class discussions, reading assignments, case studies, group projects, and "hands-on" work in database design. This course is a required professional core course for IS freshmen only.

67-260 Visualizing Complex Information

6 units

This studio course meets two times per week and teaches students how to display complex information in clear and compelling ways. Students will be taught the organizational principles of good information architecture. Assignments are centered around the visual display of complex information, with a strong emphasis on developing structures, or grids to support the display of data. Legibility, visual organization, and typographic hierarchy are tools that are implemented in all assignments. We will begin to explore the relationships between form & content, and type & image. Students will learn how to make appropriate creative decisions for large posters and small business cards, as well as multiple-page documents. Design is a process and students must show their work as it evolves. This process includes: analyzing text, organizing content, visual organization, generating pencil sketches, and producing computer iterations. Personal growth as it relates to assignments is paramount to the students' success in this class, regardless of the level of experience coming in to the class. This course is intended for Information Systems sophomores. Others may enroll by instructor permission as space is available.

67-262 Database Design and Development

Fall: 9 units

Data driven decision making is a core process of organizations. In this class students will study the principles of database management systems, their design, and development. Recent alternatives to the classical relational model will also be examined. This course is a required professional core course and is open only to sophomores in the IS major who have completed 67-250 or equivalent.

Prerequisites: (15-121 or 15-112 or 15-122) and 67-250

67-265 Design Fundamentals I: Shaping Interactions and Experiences

Fall: 9 units

This is an introductory course in interaction design, user experience, and the process of designing for people and technologies. The course introduces students to basic human-centered design research and concept development in the development of digital, service, and user experiences. Students also develop component skills in user interface design. Coursework promotes design thinking and practice for application in tech fields. Offered only on the Qatar campus.

67-272 Application Design and Development

Spring: 9 units

This course provides students with the concepts and techniques to design and develop software applications, and to understand the design process. Students will learn the importance of user-centered design and will develop a prototype of a web application as a course project. In the process of developing the application, students will learn how to design and create relational databases, how to acquire competency in new programming languages quickly, how to use the Model-View-Controller pattern to develop software applications, how to ensure technical quality in software development, and how to apply principles of user-centered design. This course is a required professional core course and is open only to sophomores and juniors in the IS major who have completed 67-250 or equivalent.

Prerequisites: 15-121 or 15-122

67-280 Special Topics: Information System Security

Fall: 9 units

This course is an introduction to information security from an information systems perspective. The course will introduce the student to fundamental concepts in information system security, including operational issues, planning, and design. Topics will include confidentiality, integrity, and availability; risk; access controls and access control frameworks; security policies; authentication strategies and issues; auditing; using cryptography; security design issues; controlling information flows; malicious logic; and applying security principles.

Prerequisite: 67-272

67-301 Networks and Telecommunications

Spring: 9 units

This course will introduce students to the basics of telecommunications, including voice, data, video, and wireless, with an emphasis on data. The course will cover both technical and business aspects of networking, and will consider regulatory and industry factors affecting telecommunication networks. Students will be introduced to the concepts and terminology of networks, including layered network models, and to practical issues involved in designing, managing, and using networks and network applications. Learning will take place through assigned readings including current issues and events in networking, class participation, and homework assignments. Grades will be based on examinations, homework assignments, and contributions to classroom discussions. For Information Systems Juniors and Seniors.

Prerequisite: 67-371

67-304 Database Design and Implementation

Spring: 6 units

This course provides an introduction to database design and implementation with a primary focus on the relational model. By the completion of this course the student will be able to appropriately use database design and implementation tools (the relational model, E-R models, normalization, and SQL) and apply knowledge of both technical and business issues related to database design and implementation to generate and evaluate alternate solutions to business situations. The course will also cover database dependability, reliability, availability, recovery, architectures, and distributed databases. Current topics in databases such as object-oriented and object-relational databases as well as data warehousing and data mining will also be presented. Projects will be completed using a "significant" relational database management system such as Oracle, DB2 or Microsoft SQL Server.

Prerequisites: 67-271 and 67-272

67-306 Special Topics: Management of Computer and Information Systems

Intermittent: 6 units

The course will provide a thorough understanding of the many responsibilities for managing technology by the organization IT resource, executives, managers, and functional end users. Concentration on IT plan and budget development with associated management, IT roles and responsibilities, system development and operations best practices, security management, IT procurement with emphasis on service and product agreements, vendor relationships, project management, and business continuity/disaster recovery. Junior or senior class standing is required. Coursework in information systems, software design, project management, or related job experience is strongly preferred, but not required due to the managerial, rather than technical, nature of the course.

67-308 Innovation Studio: Health Care Information Systems

Intermittent: 9 units

Healthcare information systems are intended to improve patient outcomes while reducing the cost of clinical care. However, with the highest per person healthcare expenditures, the United States ranks low in healthcare quality compared to other countries. Although healthcare information systems are improving, challenges persist because information workflow, human interface design, and interoperability are not emphasized. In this course, students will learn to solve real-world healthcare information systems challenges in a team-based format. Juniors and Seniors

67-309 Special Topics

Spring: 6 units

Special Topics: Information Assurance and Security [Power to the Edge: Challenges to systems survivability in a net-centric world] This course is an overview of increasingly important aspects of systems development, operation and sustainment, namely information assurance, software assurance, survivability and security. As more and more functionality and dynamic decision-making are pushed down and out into the organization (power to the edge), assurance and security concerns, with their organizational and human dimensions, impact the fidelity of the data and the very survival of the organization. Topics include overview and definitions, defense in depth, legal and policy issues, principles of survivability and information assurance, risk management, insider threat, vendor and outsourcing issues, incident management and forensics. This class is a combination of lectures, readings, and discussion groups. Students will leave the course with an understanding of the various concepts and their impacts on systems and the organization itself. Pre-requisites: Junior or Senior class standing and at least one programming course (15-110 or equivalent)

Prerequisites: 15-100 or 15-112 or 15-111 or 15-110

67-311 Database Design and Implementation

Intermittent: 9 units

Managing large databases is a core task in many information systems. In this class students will explore the underpinnings of databases as well as learn how to more effectively manage databases. Topics include relational algebra and advanced data modeling, advanced SQL queries, handling transactions, performance tuning, creating triggers, views and stored procedures, and much more. In the last part of the course we will explore NoSQL databases such as MongoDB and Redis, understanding their strengths and weaknesses as well as how to integrate them into web-based applications. Prerequisites: 67-272 or permission of instructor

Prerequisites: 67-272 or 67-371

67-312 Strategic Information Systems Management

Intermittent: 9 units

The primary focus of the course will be using Strategic Planning to develop greater alignment between Information Systems and the business, and thereby deliver greater benefit to the organization and foster excellence in the IS function. Set within the context of systems thinking, it will examine the purpose and nature of strategic planning and explore the use and value of different methods and models of strategic planning. The course will introduce students to elements of strategic IS planning including setting a strategic direction, management and measurement of performance, Enterprise Architecture and finance which define a planning framework that links investment in information resources to improved mission performance. Prerequisite: 67-373

67-315 Interaction Design for the Web

Spring: 9 units

This course explores the symbiotic relationship of design and technology. While both areas of inquiry have their own goals and concerns, meaningful products can result when design and technology are considered in unison. In this joint course between the faculty of Information Systems and School of Design, students will experience the design process from ideation to implementation on different digital surfaces. Students will develop abilities for employing research methods, forming a direction, usability testing, and creating technically sound and meaningful digital solutions. Prerequisites: 67-272 or 67-274

67-316 Human Computer Interface Design and Testing

Intermittent: 9 units

This course emphasizes team-based activities to promote engaged learning and application of user-centered design and usability testing concepts. Students who complete this course will have a good understanding of designing for user experience. The course emphasizes three themes and contexts for digital design and human-computer interaction (HCI): designing for the web, designing for mobile use, and multimodal interactive design. Students will also be exposed to a variety of usability testing methods with state-of-the-art tools such as Morae and Tobii eye tracker. Prerequisites: (67-358 or 67-317 or 67-359 or 67-315) and (67-272 or 67-274)

67-317 Mobile Web Development and Usability Testing

Intermittent: 9 units

This course is offered only at Carnegie Mellon's campus in Qatar. Designing for mobile web applications enables businesses to harness the explosive growth and new opportunities on the mobile internet, besides enabling innovation in many ways. This course emphasizes a 'mobile first' approach to responsive web design, development, and user experience. Students gain a deep understanding of the mobile web development process, the grammar of building mobile web sites, emerging web standards, and state-of-the-art mobile usability testing methods. They gain first-hand exposure to developing with HTML5 and CSS3 and applying heuristic methods and testing tools such as Morae and Tobii eye tracker, to achieve an enhanced mobile user experience. Recent reports state that 80 percent of mobile websites in the US get traffic from other regions of the world. The course will address the need for facilitating a 'global' user experience, through independent student projects that target a 'global or social' theme and deliver a complete solution involving design, development, and usability testing of a localized and responsive web site for deployment in Qatar. Prerequisites: 15-121 and 67-272

67-319 Global Technology Consulting Groundwork

Spring: 3 units

This course is by invitation only for participants in the Technology Consulting in the Global Community program. For information on the program and how to apply, see <http://cmu.edu/tcingc>.

67-323 Enterprise Systems: Concepts and Practice

Intermittent: 9 units

Enterprise systems are the trend of software today in the industry. By integrating various functions of an enterprise, Enterprise systems improve the performance of business processes. This course discusses role and function of Enterprise resource planning (ERP) systems; how they fit into an organization; analyzing business processes and ERP implementation; the ethical, global and security issues of ERP implementation; hand-on use of ERP software; ERP vendors and industry trends are also studied. Software practice and ERP case analysis are required. Prerequisite: 67-272

67-327 Web Application Security

6 units

This is a technical course designed to help students learn how to exploit web applications and to be better able as developers to defend against such exploits. The course covers the process of hacking a web application, starting with initial mapping and analysis, followed by identifying common logic flaws in web apps, database and network exploits, command and SQL injections, and the like. This hands-on course requires students to be familiar with a popular web application framework or language (such as Ruby on Rails, PHP, Django/Python, ASP.NET or the like). Prerequisite: 67-272 or permission of instructor. Prerequisite: 67-272

67-328 Mobile to Cloud: Building Distributed Applications

Fall: 9 units

Web 2.0, Mashups, Mobile Apps, and Cloud Computing are just a few of the new terms people are using to describe emerging technologies for building complex, distributed applications. Protocol standards, web services, open-APIs, increasingly more powerful mobile devices, and the Internet have enabled new possibilities for weaving complex applications using globally-distributed data and computing resources. Application development has largely left any single computer, and is distributed across a wide range of hardware and software platforms. This class will explore these developing technologies and models for structuring their complexity, while building projects that go from mobile to the cloud. Prerequisite: 67-272 (with "C" or higher) or permission of instructor. Prerequisite: 67-272

67-329 Contemporary Themes in Global Systems

Fall: 9 units

Globalization and outsourcing of information systems (IS) is a mainstay of the business environment. The decision to outsource software services to providers in distant places has many risks and thus careful management of critical success factors is essential. Likewise, products and services are being developed and delivered by teams of people in diverse locations working together. Management of these sourcing models and human capital relationships will be an increasingly important skill for students expecting to fully participate in the emerging IS marketplace of the 21st century. This course introduces the effective fundamentals of global project management and the mechanics of sourcing arrangements including offshore outsourcing. Students will also examine the effects of human diversity and cross-cultural considerations in the creation, use and management of information systems. A combination of readings, participation in class discussions, and non-technical collaborative projects will be expected of class participants. Students must have sophomore standing or higher.

67-330 Technology Consulting in the Community

Spring: 9 units

In this course, the student develops technical consulting and management skills while collaborating on-site with a community leader of a non-profit community organization or school. This service-learning course has students analyze a complex organization, then design and implement a work plan that will expand the organization's capacity to use information technology. Student consultants do not merely provide IT support, nor do they focus on system development. Rather they focus on solving organizational problems using IT solutions. In doing so, they may develop a system, or adapt open source or commercial tools as appropriate to the situation. Throughout the semester, students develop a consulting report. They learn how to use this working document to collaborate with others and to think through and communicate a strategic technology plan. Students also experience how urban community organizations function, seeing the valuable benefits these organizations provide to society. Prerequisites: 76101 and (15121 or 70451) At least sophomore standing. Prerequisites: 15-121 or 15-122 or 70-451

67-331 Technology Consulting in the Global Community

Fall: 3 units

This course is by invitation only for participants in the Technology Consulting in the Global Community program. Admitted ONLY BY Permission of Instructor

67-344 Organizational Intelligence in the Information Age

Fall: 9 units

Across all organizations people find that the actions they take affect, and are affected by, the technology, norms, procedures, culture, and members of the organization. In order to navigate through this organizational world, agents need a better understanding of social and organizational intelligence. How do organizations (and the people who populate them) acquire and then process information? In what ways have new technologies affected the norms, procedures, and culture of organizations? How do leaders successfully guide their organizations through a world where new information and new technologies are constantly being produced? This course is about information assessment and analysis in organizations, and the way organizations are transformed by technology. This course is for Sophomores, Juniors, and Seniors.

67-352 Electronic Business

Intermittent: 9 units

The objective of this course is to give students a good understanding on how e-business is conducted and managed including opportunities, limitations, issues, and risks. E-business applications require certain technological infrastructures and other support mechanism in areas of business-to-consumer, business-to-business, and consumer-to-consumer. Topics will cover the technologies, skills and business concepts that surround the emergence of electronic business and the impacts of applying these information technologies to different commercial processes from both an operational and strategic perspective. The course will also explore the problems surrounding electronic business such as security, privacy, intellectual property rights, legal liabilities and global issues. The course provides a contemporary exposure to concepts and practices associated with a new and dynamic digital environment in the real business world. The information technologies associated with the delivery of Internet sites as well as internal operations will be discussed. After completion of this course, students are expected to have appropriate level of knowledge, skills, and concept of the digital operations in a modern business world. Prerequisites: 67-272 or 67-371

67-353 IT & Environmental Sustainability

Intermittent: 6 units

Information Technology can have both negative and positive impacts on the environment. IT production, use, and disposal have real environmental impacts, and increase CO2 emissions resulting from power consumption. (The IT sector has been estimated to produce 2% of global greenhouse gas emissions.) Therefore, making the production, use, and disposal of ICT greener is essential. However, IT can help mitigate environmental degradation and reduce carbon emissions by enabling smarter cities, transportation systems, electrical grids, sensors, and business processes and management. In this course, students will learn about the impact Information Systems and Information Technology have on the environment and the role IS/IT may play as a possible solution to many environmental problems. Juniors and Seniors

67-354 Information Systems and Sustainability

Intermittent: 9 units

Environmental, economic, and societal challenges are affecting the sustainability of many communities around the globe. Given its multidisciplinary foundation, IS presents an important potential for enabling adaptation and mitigation to these challenges. IS innovation could also play a prominent role in transforming unsustainable problem spaces into sustainable and resilient systems. What is needed is sustainability minded IS professionals to lead such transformation. This course introduces students (future IS leaders) to the fundamentals of sustainability in the 21st century. It includes topics on Green IS, Smart Cities, and the Information Economy. The course invites students to proactively reflect on sustainability issues and their effects on policy and leadership. In such reflection, students are encouraged to consider various case-based scenarios where they evaluate challenges to sustainability and developed innovative, strategic, practical, and rigorously supported IS based solutions. Prerequisite: 67-272

67-357 Healthcare Analytics and Big Data

Intermittent: 9 units

The objectives of this course are: (1) to provide a sound understanding of how healthcare analytics helps to re-engineer the complex processes that drive return on investment and lower medical costs and (2) how the big data revolution is accelerating value and innovation in healthcare. Topics in healthcare business intelligence (BI) to be covered include how data quality and data governance improve the quality of healthcare, architectural implications of BI, technology management, and how BI facilitates evidence-based medicine and effective clinical decision support. Besides gaining hands-on lab experience with BI technologies and tools used in real-world healthcare organizations, students will also work on a group project to understand better the challenges that big (and unstructured) data present to traditional clinical database systems. Prerequisites: (67-250 or 70-451) and 15-121 and 36-201

67-358 Technologies in Service Design

Intermittent: 9 units

**This course is currently available only on the Qatar campus. **The course looks at designing services within systems, the process of designing human ecologies with technology products, e.g., redesigning the EC entrance gate, shaping patient experience at the hospital, or anywhere in between. Deliverables could include ambient devices, apps, wearables, embedded technologies, or other things along user pathways, all determined by the research insight. Prerequisite: 67-272

67-359 Design Fundamentals II

Spring: 9 units

This is a course study in communication design, data presentation, organization, visual hierarchy, messaging, and design production. Students explore and develop skills in the organization of qualitative and quantitative data and structure of information for strategic purposes. Projects hone component skills in production and presentation for screen using grids and appropriate typography. Incorporates basic multilingual production.

67-360 Applied Analytics

9 units

Businesses and organizations are currently in a paradoxical situation where they are drowning in data but starving for knowledge. From tracking purchases at traditional retail stores to logging browsing patterns at online stores, modern business are adept at collecting data about their customers. The analytics challenge is how to interpret and distill this data into actionable knowledge. This class will introduce you to a range of technologies and methods for extracting business intelligence from data to anticipate customer needs and create new opportunities. We will examine how various business processes can be improved with case-studies and examples from the fields of fraud detection, movie-box office, credit scoring, customer churning and retention. These are some of the analytic strategies used by companies such as Google, Amazon, Netflix, and Facebook to better understand and target their customers. The overall objective of this class is to introduce you to practical business analytics skills which are in high demand in the current job market. The class will be hands-on with various analytics tools such as the SAS Enterprise Miner. This course may count toward the Decision Science and Rational Choice (old curriculum) and Quantitative Analysis and Research Methods (new curriculum). Students could also use it as an IS elective for the professional core or content area (Quantitative Analysis and Research Methods). Prerequisite: 15-121 or consent of the instructor.

Prerequisites: 15-111 or 15-121 or 15-211 or 15-122

67-361 Big Data & Sustainability

6 units

Sustainability is one of the greatest global predicaments now facing us. Symptoms abound: climate change, depletion of water resources, deforestation, pollution, and on and on. There are no easy answers to these problems. Even framing the relevant questions is difficult. Choosing between competing alternatives runs the risk of addressing one problem at the expense of another. Only through thoughtful and careful analysis can informed, robust and helpful strategies be developed. Massive amounts of data are now available in a range of domains, e.g., telemetry, energy consumption, traffic patterns, healthcare etc. As a new resource, 'Big Data' is differentiated from traditional data by its volume, velocity, and variety. The dual combination of Big Data and technological advances in the general field of analytics and data mining currently provide an opportunity to potentially answer heretofore inaccessible questions. In the domain of sustainability, advances in sensor technology, metrology, physics based modeling, epidemiology, and ecological sciences provide an explosion of data yet to be mined. Relationships among these apparently disparate data sources have yet to be established and leveraged. In this introductory course, students will gain exposure to sustainability. We will then examine some classical analytic techniques and their limitations for the nature of problems related to sustainability. We will tie these two themes of the course together by exploring contemporary Big Data approaches to the intractable problems of sustainability. Units include: 1. Background on the problem domain (Sustainability); 2. Overview of classical Data Analytics and their limitations; 3. Introduction to Big Data and associated platforms (e.g. Apache Hadoop, IBM Watson); 4. Exploring the potential of Big Data approaches to the problems of Sustainability. For Juniors and Seniors or by instructors approval

Prerequisites: 15-112 and 36-201

67-362 Big Data and Analytics

Spring: 9 units

Massive amounts of data (terabytes and beyond) are available in a range of domains: commerce, finance, healthcare, social media, real-time process monitoring, etc. This course is an introduction to the techniques and tools for analyzing and distilling actionable knowledge from data. Sophomores, juniors and seniors.

Prerequisites: 15-112 and 36-201

67-370 Intelligent Decision Support Systems

Spring: 9 units

In this course we will study various methods for augmenting human decision making. We will focus on the key ideas of several business intelligence technologies and the value they can bring to an enterprise. The technologies we will study include classic symbolic AI methods (rule-based systems, case-based reasoning), connectionist approaches (neural nets), evolutionary approaches (genetic algorithms), inductive approaches of machine learning (nearest neighbor, support-vector machines), data mining (constructing decision trees and association rules), and collective intelligence methods (collaborative filtering). While this is not a programming intensive course, we will be using several software systems and libraries implementing these methods. By running experiments with these systems and libraries we will focus on how these technologies can support decision making in tasks such as classification, clustering, prediction, optimization, design, and recommendation. This course may count toward the Decision Science and Rational Choice (old curriculum) and Quantitative Analysis and Research Methods (new curriculum). Students could also use it as an IS elective for the professional core or content area (Quantitative Analysis and Research Methods).

Prerequisite: 15-121

67-371 Fundamentals of System Development

Fall: 9 units

This is an introductory course in software systems analysis and design and project management. The course will cover contemporary themes and issues involved in developing high quality software systems that meet users' expectations. Students will learn the basic theory, techniques and skills that systems analysts need to develop and document requirements and project plans for complex information systems projects. Since software system development practice is a rapidly evolving area, a cross-section of current, as well as time tested best practices methods will be presented. The course consists of these main components: overview of systems analysis and design, lifecycle and process issues, requirements articulation with use cases, object models and diagramming and documentation tools and techniques, and project management, including issues of software quality and metrics. Concepts will be mastered through a combination of assigned readings, class attendance, homework assignments and mini-projects. This course is a professional core requirement, and is open only to IS juniors who have completed 67-272.

Prerequisite: 67-272

67-372 Principles of Database Systems

Fall: 9 units

Building upon prior exposure to data modeling, students will study in depth principles of database management systems, their design, and development. NoSQL alternatives to the relational model will be motivated and studied. This course is a required professional core course and is open only to juniors in the IS major who have completed 67-272.

Prerequisite: 67-272

67-373 Software Development Project

Spring: 12 units

In this course, students design and implement a usable information system for a client. The client may be affiliated with the university, government, business, or non-profit agency. Students will be assigned to teams to work on these projects, and will produce operational, fully documented and tested, computer-based information systems. The projects will be supervised by CMU faculty and, when possible, by project clients.

Prerequisites: 67-272 and 67-371

67-381 The Designed World

Fall: 9 units

This is a seminar course based on rhetorical inquiry into the nature of the designed world, how to analyze it, how it's built, and the values that shape it. Surveying design across its many forms, this reading- and writing-intensive course develops critical thinking on how we design information, products, technology, physical space, services, public policy, as well as inquiry into emergent human ecologies and whole earth systems. Offered only on the Qatar campus.

Prerequisite: 76-101

67-390 Independent Study in Information Systems

Summer

Independent studies are opportunities to engage in research with an IS faculty member to advance your learning in certain areas of interest. Information Systems students may enroll in independent study for 3, 6, 9, or 12 units of academic credit by obtaining an IS faculty sponsor who will oversee the academic component of the coursework, monitor progress, and assign a final grade.

67-442 Mobile Application Development in iOS

Intermittent: 9 units

This course provides students with the concepts and techniques to design and develop mobile applications with iOS and to understand the design and development process involved. Students will develop a series of smaller iOS applications in weekly lab sessions as well as larger application as part of a course project. In the process of developing these applications, students will develop a strong understanding of the Swift programming language, iOS application development, mobile-centered design, and how to ensure technical quality in software development. This course is open only to juniors and seniors in the IS major who have completed 67-272.

Prerequisite: 67-272

67-474 Tech Startup Launchpad

Spring: 9 units

This course provides hands-on learning about what it is like to start and launch a technology startup company. You will work within a team of students to turn your idea into a real company. You will learn and apply modern concepts practiced today in top innovation hubs around the globe: lean startup, minimum viable product, customer development, product-market fit, agile product development, business model generation, competitive landscape, etc. The goal of this course is not to write a business plan, prepare a venture capital presentation, or write tedious progress reports. You will learn what it takes to quickly develop your idea into a prototype, turn it into a minimum viable product and launch it, while you concurrently 1) talk to and cultivate potential customers, and 2) develop and iterate on your business model. This course is designed for BA, CS, IS seniors; non-IS seniors should obtain instructor permission to enroll in this class.

Prerequisite: 67-272

67-475 Innovation in Information Systems

Fall: 12 units

In this capstone team-based course, IS seniors design and implement an information systems solution to meet a real-world need or opportunity. Innovation, entrepreneurship, planning, project management, and risk taking will all be emphasized. Students will be challenged to produce "proof of concept" systems or prototypes that are fully documented, tested, and ready to present for external evaluation. This course is a required professional core course and is open only to seniors in the IS major who have completed 67-373.

Prerequisite: 67-373

67-490 Practicum in Information Systems

Intermittent

The practicum in information systems allows students interested in applying skills acquired in the field of information systems in the context of a working environment. Students will complete a project and be accountable to a stakeholder that is external to their program of study. They may shadow and observe practices in the field of information systems, and also perform tasks as assigned. A hands-on experience is expected. By completing this course, students practice desirable skills for employability, such as time management, project management, team work, and professional development. *This course is offered at CMU in Qatar only.

Dietrich College Interdisciplinary Courses

66-221 Topics of Law: Introduction to Intellectual Property Law

Intermittent: 9 units

Topics for this course vary, to include such foci as intellectual property, introduction to U.S. law, great American trials, and the U.S. Constitution. Topics and courses are designed to be broadly relevant and interesting for university undergraduates, and not narrowly tailored for students interested in law school.

66-230 Elective Seminar: American Political Journalism

Intermittent: 12 units

This class will explore the relationships among politics, news media and government. It will do so by focusing on particular news events in which the role of the media became an integral part of the story. Some of the sessions may change based on guest speakers' schedules; topics of discussion and readings may also change based on breaking news events. (Class meets at Washington Post, 1150 15th Street, NW).

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-307 Independent Study**

All Semesters

This course is intended for students with a special interest in an interdisciplinary area in the humanities and/or social sciences not covered by a normal course. Readings and other works are developed by the student and an individual faculty member. The number of units will be assigned at the time of registration based on the number of hours to be completed (decided in advance with the sponsoring faculty member).

66-311 CMUWSP Elective Seminar: U.S. Foreign Policy in the Middle East

Intermittent: 12 units

NOTE: THIS COURSE IS OPEN TO CMU-WSP STUDENTS ONLY. What are the United States' interests in the Middle East? Who and what determine those interests? And how are those interests pursued? This course addresses these questions in two parts. First, we will consider the domestic American debate on foreign policy in the Middle East, exploring key Middle Eastern trends; America's regional interests; and the political actors and factors that shape U.S. policy in the Middle East. We will then turn to America's actions and relationships in the region, assessing American policy dilemmas across a wide variety of countries and events. Students should leave this class with a strong understanding of the challenges that the U.S. faces in the Middle East, as well as an informed viewpoint regarding how well America is meeting those challenges.

66-312 CMUWSP Core Seminar: The Supreme Court

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. Gay marriage. The death penalty. Abortion. Health care. Cell phone privacy. The U.S. Supreme Court has heard cases on all of these topics in recent years, and its decisions ultimately touch the lives of all Americans. In this class we will study the Supreme Court's place in the U.S. legal system. Topics we will cover include: how a case gets to the court, the justices, the role of lawyers before the court, the purpose of oral argument, the court building and its symbolism, and media coverage of the court. Readings will range from newspaper and magazine stories to law review articles. At least once during the semester students will attend an oral argument, and cases currently before the court will be used as a reference point for class discussion. This class is geared not only toward anyone who is interested in the law or government service but also toward anyone interested in working on or being informed about the biggest issues of the day.

66-313 CMUWSP Elective Seminar: Fiscal Policy-making in the U.S.

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. The purpose of this course is to give students a comprehensive overview of the major issues facing U.S. fiscal policy, with special emphasis on structural issues, such as the problems facing the major entitlement programs: social security, and Medicare/Medicaid. The course will emphasize the economic aspects of fiscal issues, but will also address their historical roots and political aspects. For example, its discussion of expenditure will address the constraints posed by the budget system and the political process on expenditure control. Similarly, it will explore how politics has shaped the tax system, and why the government policy discussion is so often stymied. Washington-based experts in the field will be included in presentations and class meetings.

66-317 CMUWSP Elective Seminar: Politics and Poems: Writing Verse in DC

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. This course is a space for writing and discussing poems in the nation's capital. The course title takes as inspiration the name of the renowned independent bookstore (Politics and Prose) in Washington, but with a twist. Accordingly, most of the assigned texts will be by DC area poets who will visit the class as special guests. This course is as much about reading poems as writing (and revising) them. Students will attend at least one live literary event to experience poetry as performance, as well as visit a museum or gallery to use the visual or plastic arts as a springboard for their poetry. Finally, students will acquire and hone the vocabulary necessary to offer constructive feedback on one another's work.

66-319 CMUWSP-Cultural Heritage, Cultural Diplomacy, and the Universal Museum

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. This course is designed to introduce students to the broad implications of the control, management, investigation, presentation, and interpretation of collections of things considered of cultural significance. A tradition of more than 400 years can be traced from the sixteenth-century European collections made by a network of nobles, merchants, and explorers to the universal museums of the nineteenth century. Many of the universal museums established in the nineteenth century persist today as national museums, and of these, the Smithsonian Institution can be taken as a model. Participants in this seminar will be introduced to the contemporary workings of museums, and will use frameworks provided to examine how constituent museums that form part of the Smithsonian can be understood as sites of knowledge creation. This course frames museums within contemporary issues of cultural heritage (repatriation, the international traffic in antiquities) and cultural diplomacy (implementation of the UNESCO Convention, development and circulation of collaborative international exhibitions). Students will gain a basic understanding of the structure of western museums; the history of the universal museum; relationships between cultural property and national identity; and contemporary cultural policy issues.

66-320 Internship

All Semesters

Internships-for-credit allow students to apply course-based knowledge in a non-classroom setting, under joint supervision and evaluation by an on-site supervisor and a faculty sponsor. Approved internships must conform to college guidelines for internships-for-credit, and are available by permission only arranged through the Associate Dean's Office in Baker Hall 154.

66-321 CMUWSP Internship Seminar

Fall and Spring: 15 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. The internship is the experiential ?core? of the Washington Semester program. Students intern three days per week, for approximately 27-28 hours, in offices from Capitol Hill to the White House and including opportunities in cabinet agencies, nonprofit institutions, museums, advocacy groups, policy think tanks, cultural institutions, and news organizations. Through the internship, students gain professional experience and make long-lasting professional and personal contacts. In addition, students meet once a week with the CMU internship faculty for a 2-hour seminar to report and reflect on their internship experiences, and address pressing current issues from the perspective of their internship organization. In addition, the weekly seminar typically includes 1-2 CMU alumni from the Washington DC area whose personal and professional experiences become part of the seminar conversation, and who make themselves available to students as ongoing sources of information and advice. Students earn 15 CMU units of credit for the internship and internship seminar.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-322 CMUWSP Race and Politics in the American City**

Fall and Spring: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. The purpose of this seminar is to equip students to think deeply and critically about racial politics in the American city in general - and about racial politics in the American city of Washington D.C. in particular. The course is a seminar. Its success depends importantly upon student preparation. Each week, students must come to class having read and thought about the readings, and prepared to participate in discussion in a constructive way. Each week students will be required to write brief papers. Their purpose is to organize the readings and shape class discussions, and they are due prior to the seminar itself. Grades will depend on the quality of weekly papers (1/3) contribution to class discussions (1/3), and a paper due at the end of the term (1/3). The seminar will begin with an introduction to a set of concepts fundamental to our subject ? race, consciousness, racism, political action - and then move on to central features of city politics with race prominently in mind.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-323 Core Seminar: Congress**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. This thematic research seminar will explore the workings of Congress - the first branch under the Constitution - and its role in making public policy. It combines coursework with the original scholarship requirements of a UCDC research seminar and is designed particularly for students in Congressional internships and those considering Congressional staff positions after graduation. This seminar will take advantage of our Washington location by featuring frequent guest speakers and seeking connections to current policy and political debate. In addition to studying the pathways of lawmaking, we will ask how Congress and its Members relate to the other branches of government, the press, and the public. Topics to be examined include the rules and organization of Capitol Hill, campaign finance, redistricting, lawmaking and the House and Senate rules, budget process and politics, executive oversight, judicial nominations, lobbyists and influence, and policy entrepreneurialism. Seminar requirements in addition to the internship include preparation and in-class participation, a substantial research brief and several applied writing assignments related to a policy that currently is or should be before Congress.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-324 Core Seminar: Washington Media**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. This seminar will explore the rapidly changing relationship between the news media, political communication and governing. Washington offers the perfect backdrop with the opportunity to visit iconic institutions, such as the White House Press Room, Washington Post and Newseum, as well as the chance to witness up close the work of journalists, politicians and other political communicators at the top of their profession. Students will keep abreast of current political news in addition to readings on the practice and history of political journalism, communication and propaganda. Each student will complete an original research project, some of which may be adapted for publication in a California news outlet. The course is designed particularly, though not exclusively, for students interning at news organizations, political press offices, speechwriting groups, public relations firms or those with a passion for writing or politics. The instructor is veteran journalist Marc Sandalow, former Washington Bureau Chief for the San Francisco Chronicle, political analyst, and the author of a biography on House Speaker Nancy Pelosi.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-325 Core Seminar: General Research**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. In this seminar each student will research, write, and present the findings of a major, original research paper. The paper (approximately 25 pages) should build on your major field of study and related in some way to your internship experience. The class will help guide you through the many stages of a research project: 1) selecting a meaningful question or problem that you wish to investigate; 2) reviewing existing scholarly writing on the topic in order to better articulate why your contribution is fresh and significant; 3) organizing and revising drafts of your paper; 4) designing and effectively delivering an oral presentation of your findings. As we help each other negotiate these steps, we will also consider issues related to what constitutes ?expertise? and why researchers may present competing evidence and conclusions. The class may include some guest speakers from and visits to some of the many research institutes in Washington.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>

66-326 Core Seminar: The Presidency and Executive Branch

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. The White House, located in the heart of downtown Washington and just a ten minute walk from UCDC, is an international symbol that simultaneously highlights the lofty promise of American democracy and reflects the significant flaws in the American experiment. The research seminar will examine the strengths and drawbacks of presidential leadership, the evolving role of the presidency in American culture, and introduce students to some major thematic debates that define presidential politics. The seminar will draw on the city of Washington as an experience through visits to current and former White House aides, news correspondents, and political and policy experts. Seminar topics include how presidents have sought to enact their reform agendas from the New Deal to Reagan's economic program to President Obama's health reform law; how they have struggled to manage foreign affairs while leading the U.S. in wartime; why Congress, the Supreme Court, and the news media thwart and assist presidential agendas at different moments; how presidents have harnessed the "bully pulpit" in the modern age to rally voters to their ideas, push their policies, and position themselves for re-election; and how they have pursued strategies to manipulate a highly volatile, increasingly hostile Washington media climate.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-327 Core Seminar: International Policy and The Global System of the 21st Century**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. This course's first objective is to provide academic background and guidance to students whose internships involve international policy, international organizations, globalization, and international relations in general. Its second objective is to introduce participants to the latest literature and current debates on international and global change. What are the major actors in the international political arena of the 21st century? What are the characteristics of governmental, non-governmental, and intergovernmental actors engaged in international policy making? Can we somewhat appraise the type of international system that we will live under during the next decades? Will the United States continue to be a major global power? In order to take advantage of our location in Washington, I will bring in practitioners from different policy communities to speak to us about their work. I will also invite some journalists and academics.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-328 Elective Seminar: Lobbying, Money and Influence in Washington**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. This course will be an intense examination of lobbying in Washington with particular attention given to the role of money and campaign finance in the operation of what has become a highly sophisticated and poorly understood network of advocacy and influence. It will provide a basic understanding of three different but interrelated knowledge sets: the Congress, political money and lobbying by interest groups. Student should understand that while the lectures are focused on those individual subject areas and that the semester is divided into three separate sections for that purpose, the readings later in the term will often relate to earlier lectures. This is done with the intent of "connecting the dots" among all these somewhat diverse topical areas.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-329 Elective Seminar: Green Governance**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. How do we create a more sustainable world? What is the role of energy and environmental policy? Will technical innovation lead to better solutions? What is the role of the consumer? Should business climate change planning be under government mandate or voluntary? Will market-based solutions work? What metrics should we use to determine the relative effectiveness of various policies? These are the sorts of questions we will ask in this course. We will look at climate change and other pollution control policies. We will also look specifically at the metrics used to determine whether various forms of governance are effective, including life-cycle analysis, carbon footprint calculations, ranking procedures, etc.. Student groups will work collaboratively to complete a set of wiki-based labs that introduce students to these methods. Based on what they learn, students will write a research paper covering a current topic in the public debate about various forms of energy and environmental governance - including market-based, government and consumer-based and social movement centered options - to deal with our current sustainability challenges.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-331 Elective Seminar: Spies! The Politics of Intelligence**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. In this course students will be introduced to recent issues concerning intelligence, such as intelligence failure, reform, and oversight, focusing particularly on how the change in US intelligence in the post-9/11 context has increasingly emphasized domestic - or "homeland" - intelligence. Students will gain a working understanding of the different types of intelligence, the range of responsibilities that the different IC members hold, and the relationship between intelligence and the policy-making process. Beyond the technical aspects of the intelligence function, students will explore the political context that frames intelligence operations and learn how the three branches of government both collaborate and conflict to utilize this resource. They will learn how integral intelligence information is to high-level government decision-making and the function of foreign policy. Finally, students will consider some of the major normative questions regarding intelligence, such as: what the appropriate role for intelligence should be in a democracy, how transparent intelligence should be to the public, and how its vast array of activities should be supervised.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-332 Elective Seminar: The Theater of Politics**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. Over the years, this course has canvassed the Washington theater scene and discovered a wealth of politically and socially attuned material on DC stages. Washington has, rather surprisingly, emerged as the second most vibrant theatrical city in the nation, surpassing Chicago and Los Angeles in number of performances offered, audience in attendance, and union actors appearing in Equity-contracted productions. The city now boasts some of the finest classical flagship and culturally specific theaters in the country. This advent of a robust theater scene planted in the seat of power has created a unique cultural profile; that of an artistic force able to speak truth to power. Yet oftentimes, theatrical institutions are constricted by the divided nature of the audience they play for, or the critical community that critiques them, or differing notions about the purpose of theater. What kind of portraits are emerging from area theaters in this politicized capital? What are the practical politics within these institutions that seek to engage and entertain their patrons? In addition to introducing students of the wonders of consistent theater-going with dynamic post-performance discussions with the artists who make the art, our focus will concern politically oriented works.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-334 Elective Seminar: Campaigns and Elections**

Intermittent: 12 units

NOTE: THIS COURSE IS FOR CMU WASHINGTON SEMESTER STUDENTS ONLY. This class will teach you how to better understand the fundamental factors that drive elections in America and to learn some of the skills employed by political professionals. Many of your assignments will require you to apply the lessons of this class to real time events. Pundits and other observers have already generated a phenomenal amount of analysis and commentary about the 2012 election - and occasionally they have even been right. The goal in this class is to go beyond the spin and hyperbole of many election commentators and understand how voters decide and how strategists persuade. And, to give you some of the technical skills to get an interesting job with a campaign. This class will combine the insights of campaign professionals with insight from the study of previous campaigns and core academic knowledge. It will combine theory, practice, and exploration, taking the insights of political scientists and political practitioners and rolling them into one.

Course Website: <http://www.cmu.edu/ir/washington-semester-program/>**66-501 H&SS Senior Honors Thesis I**

Fall and Spring: 9 units

This sequence is open only to those seniors who have been admitted to the H&SS Senior Honors Program. This is the first semester of a two-semester sequence that culminates in an original, year-long independent research or creative project. Thesis topics are selected by faculty and students.

Course Website: <http://www.cmu.edu/dietrich/undergraduate/programs/shp/index.html>

66-502 H&SS Senior Honors Thesis II

Fall and Spring: 9 units

This sequence is open only to those seniors who have been admitted to the H&SS Senior Honors Program. This second semester course is the culmination of an original, year-long independent research project. Research topics are selected by faculty and students.

Prerequisite: 66-501

Course Website: <http://www.cmu.edu/dietrich/undergraduate/programs/shp/index.html>

Drama Courses**54-011 Warmup**

Fall: 1 unit

Drama majors only.

54-012 Warmup

Spring: 1 unit

Drama majors only

Prerequisite: 54-011

Corequisite: 54-102

54-101 Acting I

Fall: 10 units

A knowledge and beginning understanding of the components of acting. Basic exercises, improvisations and prepared work in relaxation, concentration, imagination, communication. The ability to create the reality of a given situation in theatrical terms. Craft fundamentals in preparation for scene study. The beginning development of the students creative resources. This course is open to Drama majors only.

54-102 Acting I

Spring: 10 units

A knowledge and beginning understanding of the components of acting. Basic exercises, improvisations and prepared work in relaxation, concentration, imagination, communication. The ability to create the reality of a given situation in theatrical terms. Craft fundamentals in preparation for scene study. The beginning development of the students creative resources. This course is for Drama majors only.

Prerequisite: 54-101

54-103 Speech I

Fall: 6 units

(Speech & Phonetics) The course introduces students to the pronunciation of the sounds of the Standard American English Dialect. The International Phonetic Alphabet (IPA) is used to teach the students a symbol for each vowel, diphthong and consonant sound of the dialect. This process will strengthen the student's production of the thirty-nine sounds and will eliminate regional characteristics. Intonational patterns of the dialect are also studied and practiced. The work is applied to weekly presentations of poetic texts. Phonetic transcription is required of class participants from the beginning of this course. This course is for Acting and Directing majors only.

54-104 Speech I

Spring: 6 units

(Speech and Phonetics) The second semester is a continued investigation and drill of the thirty-nine sounds of the Standard American English Dialect as well as the music of the dialect. Students apply the principles of the five degrees of stress of the dialect, inflections and intonational patterns and the use of the weak forms of certain parts of speech of the English language to the weekly presentations. The last four weeks of this semester are focused on preparation for a public performance of each student's favorite poet's poetry, all of which is memorized and transcribed phonetically. This course is for Acting and Directing majors only.

Prerequisite: 54-103

54-105 Voice/Alexander I

Fall: 5 units

Introduction to basic speaking voice and Alexander Technique work. Actors explore building a vocal preparation employing the principles of the Alexander for actor's speaking voice through explorations that help develop awareness of the head, neck torso relationship and the movement of the spine; vocal release, breath support, stamina. range, use of resonators and the application to text. Actors learn to identify components of healthy and unhealthy voice usage, basics of vocal anatomy and strategies for maintaining vocal health. Writing exercises are employed to help actors connect the voice to creativity and imaginative, essential for the actor's development.

54-106 Voice/Alexander I

Spring: 5 units

Introduction to basic speaking voice and Alexander Technique work. Actors explore building a vocal preparation employing the principles of the Alexander for actor's speaking voice through explorations that help develop awareness of the head, neck torso relationship and the movement of the spine; vocal release, breath support, stamina. range, use of resonators and the application to text. Actors learn to identify components of healthy and unhealthy voice usage, basics of vocal anatomy and strategies for maintaining vocal health. Writing exercises are employed to help actors connect the voice to creativity and imaginative, essential for the actor's development.

Prerequisite: 54-105

54-107 Movement I

Fall: 4 units

This course serves as a foundation for all future movement studies. Kinesthetic awareness and responsiveness is developed through the introduction of the Viewpoints method of physical training. The importance of physical expressivity and specificity in storytelling is achieved by the creation of physical movement based compositions. This is a required course for all first year undergraduate Acting and Musical Theatre and Directing students. Other students may register for this course only with the instructor's permission.

54-108 Movement I

Spring: 4 units

This course focuses on the ability to make physically specific choices in order to convey character through an introduction to the basic principles of Laban Movement Analysis and further work in the Viewpoints method of actor training. This course is required for all first year undergraduate Acting and Musical Theatre majors

Prerequisite: 54-107

54-109 Dramaturgy 1: Approaches to Text

Intermittent: 9 units

This class focuses on building the skills and knowledge necessary for a dramaturgical analysis of plays for production. Course readings introduce students to key theoretical approaches to literature that can provide new insights and interpretations of plays. Course assignments involve students in dramaturgical research, oral presentation, and critical writing on the plays we read. Required for Freshmen Dramaturgs; open to other majors with instructor permission.

54-110 Text for Actors

Fall: 2 units

This class is in conjunction with Acting I in the School of Drama. The actor/director learns how to investigate the written text and translates it actively for performance.

Corequisite: 54-101

54-111 Text for Actors

Spring: 2 units

This class is in conjunction with Acting I in the School of Drama. The actor/director learns how to investigate the written text and translates it actively for performance.

54-117 Design Collaboration Project

Spring: 2 units

TBA

54-119 Vocal Technique

Fall: 1 unit

Singing technique for first-year Music Theatre students.

54-121 Directing I: Sources

Fall: 9 units

An interdisciplinary exploration of the directors art through the study of modern art movements. Students will be required to do extensive research on one specific movement i.e. Surrealism or abstract expressionism, and create a performance piece based on the visual and social elements of that particular movement.

54-122 Directing I: Sources

Spring: 9 units

A continuation of the previous semester focusing on Music and Dance of the twentieth century and how they influence the directors art.

Prerequisite: 54-121

54-123 Ballet I

Fall: 5 units

This course uses Classical technique (Ballet) to build body placement, alignment and muscular strength and flexibility. Designed to help the student develop a way of learning how to work and train for any dance form. This technique is the basis of the choreography in American musical theater. This course is for Music Theatre majors only. Permission of instructor.

54-124 Ballet I

Spring: 5 units

This course continues Classical technique (Ballet) to build body placement, alignment and muscular strength and flexibility. Designed to help the student develop a way of learning how to work and train for any dance form. This technique is the basis of the choreography in American musical theater. This course is for Music Theatre majors only. Prerequisite: 54-123 and permission of instructor.

Prerequisite: 54-123

54-125 Music Skills I

Fall: 4 units

The students explore the basics of music theory, which includes intervals, rhythm, notation and musical vocabulary. Emphasis is on acquiring these basic skills through sight singing.

54-126 Music Skills II

Spring: 4 units

The students explore the basics of music theory, which includes intervals, rhythm, notation and musical vocabulary. Emphasis is on acquiring these basic skills through sight singing.

Prerequisite: 54-125

54-151 Stagecraft

Fall: 15 units

The stagecraft class is designed to provide an introductory level of technical training in all the theatrical technical disciplines over the course of two semesters. The intent is to produce people who can capably fill roles on production crews and perhaps serve as an assistant to the head of the crew. Course content will cover materials, tools & equipment, procedures, safety and operations for Carpentry, Props, Paints, Metals, Costumes, Lights, Sound, Rigging, and Run Crew. As well as providing opportunity and experience to grow as technicians, this content will also help establish a foundation to begin the process of becoming managers and designers. As craft skills are often best communicated in a master/apprentice environment this course is set up as a mentored practical experience. This course will require additional time during the evening and on weekends.

54-152 Stagecraft

Spring: 11 units

The stagecraft class is designed to provide an introductory level of technical training in all the theatrical technical disciplines over the course of two semesters. The intent is to produce people who can capably fill roles on production crews and perhaps serve as an assistant to the head of the crew. Course content will cover materials, tools & equipment, procedures, safety and operations for Carpentry, Props, Paints, Metals, Costumes, Lights, Sound, and Rigging. As well as providing opportunity and experience to grow as technicians, this content will also help establish a foundation to begin the process of becoming managers and designers. As craft skills are often best communicated in a master/apprentice environment this course is set up as a mentored practical experience. This course will require additional time during the evening and on weekends.

54-157 Basic PTM

Fall: 6 units

Students in the Basic PTM course are exposed to the very fundamentals, the primitives, of entertainment technology. The intent is to provide the absolutely strongest beginning for all the work to come, to provide a solid foundation for students and instructors to build upon. Production professionals routinely perform organizational tasks. In order to be able to meet that challenge, students will need to build a toolkit of information and procedures. That toolkit will be comprised of knowledge of the kinds of parameters and techniques that are normally selected, the indices that parameters and techniques are evaluated against, and many of the wide range of issues that might point a manager toward one decision or another. There also exists an entire pantheon of information that people typically learn "on the job." Activities and information presented in this course are designed to try to expose students to as much of this on the job type development as possible with the goal of leapfrogging them past the bottom rung of the workplace ladder. Drama Design/Production majors only, or with instructor permission.

54-158 Basic PTM 2

Spring: 6 units

Students in the Basic PTM course are exposed to the very fundamentals, the primitives, of entertainment technology. The intent is to provide the absolutely strongest beginning for all the work to come, to provide a solid foundation for students and instructors to build upon. Production professionals routinely perform organizational tasks. In order to be able to meet that challenge, students will need to build a toolkit of information and procedures. That toolkit will be comprised of knowledge of the kinds of parameters and techniques that are normally selected, the indices that parameters and techniques are evaluated against, and many of the wide range of issues that might point a manager toward one decision or another. There also exists an entire pantheon of information that people typically learn "on the job." Activities and information presented in this course are designed to try to expose students to as much of this on the job type development as possible with the goal of leapfrogging them past the bottom rung of the workplace ladder. PREREQUISITES: Declared Design/PTM focus in the School of Drama FOR: First Year Undergraduate Students

54-159 Production Symposium I

Fall: 6 units

Hands on experience in most aspects of building and running a production.

54-160 Production Symposium I

Spring: 6 units

Hands on experience in most aspects of building and running a production.

54-162 Introduction to Costume Design

Spring: 6 units

A rigorous introductory studio course for newly declared School of Drama Costume Design Sophomores in their fourth semester of matriculation. Basics of the design process are covered as well as drawing, sculpture, semiotics, play and character analysis, research and character building are explored. An intensive collaboration project with students of other design disciplines comprises the second half of the course. PREREQUISITES: Basic Design-54-171 and 54-172. All others: interview/portfolio review and instructor permission. FOR: 3rd semester Sophomore Costume Designers and students outside of School of Drama. IDEATE. Prerequisites: 54-171 and 54-172

54-163 Production for Non Majors

Fall: 6 units

Basic introduction for non-majors to backstage operations through practical experience handling scenery, costumes, props and lighting. Orientation session offered in fall required prior to taking this class. Contact instructor to register and discuss limited openings

54-164 Production for Non Majors

Spring: 6 units

Basic introduction for non-majors to backstage operations through practical experience handling scenery, costumes, props and lighting. Orientation session offered in fall required prior to taking this class. Contact instructor to register and discuss limited openings

54-166 Introduction to Sound Design for Theatre

Spring: 6 units

Students explore the basic principles and theories of sound design from technical, psychological and aesthetic standpoints. Course work includes instruction in the controllable properties of sound, practical planning of sound plots, cue creation, and the design process. Prerequisites: Basic Design and Design For The Stage. Drama majors have priority, however this course is also open to Music Technology majors and minors, or with permission of instructor.

Prerequisites: 54-171 and 54-172 and 54-231

54-169 Studiocrraft

Fall: 13 units

The studiocrraft course provides beginning level instruction in Drawing, Hand Drafting, and CAD Drafting.

54-170 Studiocrraft

Spring: 8 units

The studiocrraft course provides beginning level instruction in Drawing, Hand Drafting, and CAD Drafting for Design/PTM majors.

54-171 Basic Design

Fall: 6 units

A year-long studio course that explores the principles and elements of design utilizing discreet exercises and projects first semester. Research and reports expose the students to designers, theatres and artists of note in the world. Second semester focuses on the semiotics of the visual and aural aspects of theatrical design. Projects fold in each of the disciplines of scene, costume, lighting, sound and media design. PRE-REQUISITE: Declared Design/PTM focus in the School of Drama. FOR: First Semester Design/PTM Undergraduate Students only .

54-172 Basic Design

Spring: 6 units

A year-long studio course that explores the principles and elements of design utilizing discreet exercises and projects first semester. Research and reports expose the students to designers, theatres and artists of note in the world. Second semester focuses on the semiotics of the visual and aural aspects of theatrical design. Projects fold in each of the disciplines of scene, costume, lighting, sound and media design. PRE-REQUISITE: Declared Design/PTM focus in the School of Drama. FOR: First Semester Design/PTM Undergraduate Students only

54-175 Conservatory Hour

Fall: 1 unit

A year-long discussion class for first-year Drama students. Open to non-majors interested in declaring a Drama minor.

54-176 Conservatory Hour

Spring: 1 unit

A year-long discussion class for first-year Drama majors. Open to non-majors interested in declaring a Drama minor.

54-177 Foundations of Drama I

Fall: 6 units

In this course, students receive training in the basic analysis of scripts to determine key elements of structure, plot, characterization, thematic content, theatricality, and aesthetics. In addition, the course provides training in dramaturgical research and writing. Registration for this course is limited to Drama majors and minors. All other majors must receive the instructor's permission.

54-178 Foundations of Drama I

Spring: 6 units

In this course, students receive training in the basic analysis of scripts to determine key elements of structure, plot, characterization, thematic content, theatricality, and aesthetics. In addition, the course provides training in dramaturgical research and writing. Registration for this course is limited to Drama majors and minors.

54-184 Dramaturgy 2: Introduction to Production Dramaturgy

Intermittent: 9 units

This class continues the basic skill training of the dramaturg, emphasizing the history of world theatre from a dramaturgical perspective, a broad grounding in the history of critical theory of drama, and skill-building exercises in research, presentation, and writing. Required for Freshmen Dramaturgs; open to other majors with instructor permission.

54-187 Introduction to Playwriting

Fall: 9 units

Students will be introduced to the major components of writing for the stage, including dramatic action, character, and dialogue. Exercises designed to familiarize students with the tools available to the playwright will be assigned, and readings of exercises and works-in-progress will take place on a weekly basis.

54-188 Introduction to Playwriting

Spring: 9 units

Students will be introduced to the major components of writing for the stage, including dramatic action, character and dialogue. Exercises designed to familiarize students with the tools available to the playwright will be assigned each week. Readings of exercises and works-in-progress will take place on a weekly basis. In addition to reading each other's work, members of the class will also serve as the first test audience for your colleagues. Students will be expected to discuss their reaction to each exercise that is read. The final project for the course will be the completion of the first draft of a Ten-Minute play.

54-189 Advanced Playwriting

Fall: 9 units

This course is intended to continue the process of familiarizing students with the basic components of dramatic writing, paying particular attention to the most basic building block of all effective plays — dramatic action. We will also focus on the development of an effective structure for a one-act play, and on finding theatrical conventions which both suit the story and make it live on stage. In some cases, students may work on a long play with permission of instructor. Readings will focus on contemporary plays that suggest effective alternative structures and unique uses of theatrical language. Prerequisites: 54187
Prerequisites: 54-187 or 54-188

54-190 Advanced Playwriting

Spring: 9 units

This course is intended to continue the process of familiarizing students with the basic components of dramatic writing, paying particular attention to the most basic building block of all effective plays — dramatic action. We will also focus on the development of an effective structure for a one-act play, and on finding theatrical conventions which both suit the story and make it live on stage. In some cases, students may work on a long play with permission of instructor. Readings will focus on contemporary plays that suggest effective alternative structures and unique uses of theatrical language. Prerequisites: Introduction to Playwriting, or instructor permission.
Prerequisites: 54-187 or 54-188

54-191 Acting for Non-Majors

Fall: 9 units

This class is designed for non-acting majors and introduces the student to the basic principles of acting, character study and improvisation. One semester course.

54-192 Acting for Non-Majors

Spring: 9 units

This class is designed for non-acting majors and introduces the student to the basic principles of acting, character study and improvisation. One semester course.

54-193 Comedic Writing for Film and Television

Fall: 9 units

This course is designed to introduce basic screenplay structure and formatting through the exploration of various comedic genres including satire, farce, romantic comedy, mockumentary, and more. Students will read, view, and discuss examples of great comedic writing from contemporary and classic film and television. This course will also touch on the basics of character development and plot structure and is appropriate for writers of all levels. A short film or half-hour TV pilot will be completed by the end of semester, in addition to other writing exercises and assignments.

54-194 Introduction to Screenwriting

Spring: 9 units

This course is designed to introduce basic screenplay structure and formatting. Readings and films to see will be assigned. A short film or step-outline of a full length film are to be completed by the end of semester.

54-195 Advanced Screenwriting

Fall: 9 units

This course is designed to give writers a variety of tools they can use in writing or rewriting a current project full-length screenplay. There will films assigned to watch and analyze. Either a first draft or a rewritten version of a full length screenplay is to be completed by the end of the semester. By permission only.
Prerequisites: 54-193 or 54-194

54-196 Advanced Screenwriting

Spring: 9 units

This course is designed to give writers a variety of tools they can use in writing or rewriting a current project full-length screenplay. There will films assigned to watch and analyze. Either a first draft or a rewritten version of a full length screenplay is to be completed by the end of the semester. Prerequisite Introduction to Screenwriting, or instructor permission.
Prerequisites: 54-193 or 54-194

54-200 Dramaturgy Forum

Fall and Spring: 1 unit

Programmed and taught by senior students in the Dramaturgy program, this course is required for all Dramaturgy majors and meets once per week to discuss issues and topics of significance to the dramaturgy community.

54-201 Acting II

Fall: 12 units

Scene study: the fundamental techniques needed to participate in the developing conflict within the imaginary world. Character building through unfamiliar behavior and beliefs; relationships; language. Spring semester: The use of classical texts and ensemble playing. The deepening of the actors inner resources to be supported by the craft techniques. Prerequisites: 54-101 and 54-102

54-202 Acting II

Spring: 12 units

Scene study: the fundamental techniques needed to participate in the developing conflict within the imaginary world. Character building through unfamiliar behavior and beliefs; relationships; language. Spring semester: The use of classical texts and ensemble playing. The deepening of the actors inner resources to be supported by the craft techniques. Prerequisite: 54-201

54-203 Voice and Speech II

Fall: 5 units

The actors take a more concentrated approach to elevated text. The course focuses on the effective production of classical text. The warm up sessions are geared towards preparing the student actors for the extravagant language from Shakespeare's plays and sonnets. Meter, imagery and further specific text work is also employed to encourage each student to find clear shape in the work. A repertoire of at least five classical monologues will come from the course work. Prerequisites: 54-103 and 54-104

54-204 Voice and Speech II

Spring: 6 units

The actors take a more concentrated approach to elevated text. The course focuses on the effective production of classical text. The warm up sessions are geared towards preparing the student actors for the extravagant language from Shakespeare's plays and sonnets. Meter, imagery and further specific text work is also employed to encourage each student to find clear shape in the work. A repertoire of at least five classical monologues will come from the course work. Prerequisites: 54-103 and 54-104 and 54-203

54-205 Ballet II

Fall: 3 units

This course is designed to build on the technical foundation, work habits and professional behavior established in Ballet I. The material presented expands the classical dance vocabulary to the next level of difficulty. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor Prerequisites: 54-123 and 54-124

54-206 Ballet II

Spring: 3 units

This course continues to build on the technical foundation, work habits and professional behavior established in Ballet I. The material presented expands the classical dance vocabulary to the next level of difficulty. Course closed: Only for Music Theatre majors in Drama. Prerequisite: 54-205

54-207 Movement II

Fall

This entire term focuses on the Neutral Mask, a completely non-verbal masked movement form, through which actors search for a neutral base, both physically and psychologically, a place of complete presence in the present. The mask allows them to uncover all that is emotional in the body, the "baggage" carried from role to role, and provides techniques to free them from these limitations. Identifications with other forms of energy, the four elements, seasons, materials, colors and plant life give students new insights into the process of character development. The Neutral Mask work is immediately reinforced with applications to scene work in Acting class. Limited to Acting/MT majors only. Prerequisites: 54-107 and 54-108

54-208 Movement II

Spring: 3 units

This term is divided between two classic physical forms: Commedia dell'Arte and Clowns. In the first half of the semester students wear the half-masks of the archetypal Commedia characters (Harlequin, Pantalone, et al), to learn their psychology and physicality, improvise on historical and contemporary scenarios, and apply Commedia technique to modern comedy. Commedia dell'Arte gives them the tools to tackle physical comedy from any era, past or present. In the second half of the term students discover their personal Clowns. This clown has nothing to do with the American Barnum & Bailey Circus clown; this is not a character or caricature, but rather a revelation of the clown each student hides under the mask of adulthood. Discovering this clown gives them all a way to laugh at themselves, to uncover what makes each individual uniquely funny; it also lets them see how we only laugh at truth and in the personal material lies universal humor. Inside this freedom is the technique to know what's funny and why, and the ability to apply these rules in comedy. Prerequisites: 54-107 and 54-207 and 54-108

54-209 Lab Review Prep for Dramaturgs and Directors

Spring: 3 units

TBA

54-211 Actor Dance II

Fall: 3 units

This course introduces the basic, fundamental vocabulary of Classical technique (Ballet) to train the body in proper alignment, placement, and muscular strength. Course closed: Only for Acting majors in Drama. Prerequisite: Permission of instructor Prerequisites: 54-101 and 54-102

54-212 Actor Dance II

Spring: 3 units

A continuation of Classical technique (Ballet) and a unit of social dance styles, waltz, polka, foxtrot, tango, swing. Course closed: Only for Acting majors in Drama. Prerequisites: 54-101 and 54-102 and 54-211

54-213 Singing for Actors II

Fall: 3 units

The students have a class voice experience which includes a physical and vocal warm-up and discussion and practice of healthy singing technique. There is group and individual rehearsal of potential audition and performance material. Toward the end of the term, there are weekly opportunities to perform in public, thus preparing for auditions. Prerequisites: 54-101 and 54-102

54-214 Singing for Actors II

Spring: 3 units

The students have a class voice experience which includes a physical and vocal warm-up and discussion and practice of healthy singing technique. There is group and individual rehearsal of potential audition and performance material. Toward the end of the term, there are weekly opportunities to perform in public, thus preparing for auditions. Prerequisites: 54-101 and 54-102

54-217 Jazz II

Fall: 2 units

This course is designed to incorporate the strength of classical dance technique to a jazz dance style. Training the body in a variety of contemporary Jazz styles, i.e. Latin, Blues, Lyric, African, using body isolations and rhythmic patterns. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor Prerequisites: 54-124 and 54-123

54-218 Jazz II

Spring: 2 units

This course continues to incorporate the strength of classical dance technique to a jazz dance Training the body in a variety of contemporary Jazz styles, i.e. Latin, Blues, Lyric, African, using body isolations and rhythmic patterns. Course closed: Only for Music Theatre majors in Drama. Prerequisite: 54-217 and Permission of instructor Prerequisite: 54-217

54-219 Music Theatre Literature and Repertoire

Fall: 4 units

The students are exposed to many music scores of the basic choral and musical theatre literature. The students learn this repertory, reinforcing the principals of music theory learned in the first year. Prerequisites: 54-125 and 54-126

54-221 Directing II: Fundamentals

Fall: 9 units

Directing II This is a fall-semester course for 2nd-year Directing students and others with special permission introducing the fundamentals of the director's craft: text analysis; the concept of Action & Change, directors units & transitions) Visual Vocabulary & Staging. Tools including planes, levels, body positions, composition, picturization, emphasis & movement, and the ground plan. Work includes unscripted exercises, scene breakdowns, detailed character analysis, and a final 7 to 10 minute devised performance

54-222 Directing II: Fundamentals

Spring: 9 units

A continuation of the work done in the first semester of Directing II. This course is for Directing sophomores and BXA Directing students only. Prerequisite: 54-221

54-223 Tap II

Fall: 2 units

This course trains the student to develop a comfort level to execute percussive sounds, in a variety of percussive rhythmic patterns while applying the technical foundation of alignment and placement from classical technique. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor
Prerequisites: 54-123 and 54-124

54-224 Tap II

Spring: 2 units

This course continues to technically train the student in a variety of percussive rhythmic patterns. Course closed: Only for Music Theatre majors in Drama.r
Prerequisite: 54-223

54-226 Acting a Song

Spring: 4 units

Mines the personal life experience to bridge the gap between the Performer and the Song Lyric. Exercises are designed to break down internal blocks built by the expectation of Technical Perfection. The visceral is valued over the intellectual when approaching the Song Material. The students are exposed to groups of composers divided into units including Gershwin, Porter, Rogers and Hammerstein, Bernstein, Coleman, Sondheim to the present composers. Each student prepares and performs the given songs and receives critique and instruction from each of the music and the acting teachers.
Prerequisite: 54-219

54-229 Amy Needs a Name

Fall: 9 units

Drama majors only. Required for all Sophomore Design and Production majors. Bring tools.
Prerequisite: 54-172

54-230 Make-Up for Designers

Spring: 6 units

This is a lecture/demonstration and lab course exploring the principles of stage makeup. The course is designed to provide the theatrical designer with a working knowledge of broad-based application procedures, materials, and techniques. The course also explores the principles of characterization allowing for the development and execution of effectual makeup designs.

54-231 Design for the Stage

Fall: 9 units

This course is divided into four minis to introduce the student to the design process for costumes, lighting, scenery and sound. For Drama majors only, or instructor permission
Prerequisite: 54-171

54-232 Design for the Stage

Spring: 9 units

This course deals with the fundamental needs and responsibilities of the scenic and costume designer. Emphasis is on the development of ideas based on a dramatic text. Students are asked to interpret a text and create a visual statement based on that interpretation through the design process. Studio work is included in the course work.

54-237 Scenic Painting I

Fall: 6 units

This is a one semester studio course in the foundations of scenic painting for theater and related fields. Students will complete projects that address the following topics: preparation of and paint techniques for both soft goods and hard covered surfaces, drawing and painting to scale, representing textures in both 2 and 3 dimensions, and color mixing. Subject matter changes often and may include: architecture, natural and man-made textures, drapery, interior/exterior scenes, the human figure, still life objects.

54-238 Scenic Painting II

Spring: 6 units

This is a studio course in the foundations of scenic painting for theater and related fields. Students will complete projects that address the following topics: preparation of and paint techniques for both soft goods and hard covered surfaces, drawing and painting to scale, representing textures in both 2 and 3 dimensions, and color mixing. Subject matter changes often and may include: architecture, natural and man-made textures, drapery, interior/ exterior scenes, human figure, still life objects.

54-239 History of Architecture and Decor 1: Ancients to Gothic

Fall

This course is a survey of architecture, furniture and interiors from ancient times to the Gothic period. A lecture/slide course, the discussion of architecture is done with reference to social, political and economic history.

54-240 History of Architecture and Decor 2: Renaissance to the 21st Century

Spring

This slide/lecture course is a survey of architecture, interiors and furniture from the Italian Renaissance to the beginnings of the 21st Century.

54-242 Improvisation

Spring: 2 units

This course is for Sophomore Actors only. This course not only sharpens their skills as ensemble performers, but also allows for more playfulness, creativity and exploration, cultivating risk-taking and a certain abandon. The course concentrates on non-verbal psychological improv, helping actors achieve a kind of physical truth and spontaneity, while becoming aware of the importance of the body in conveying information.
Prerequisites: 54-101 and 54-102

54-245 History of Clothing

Fall: 6 units

This year-long course surveys the development of garments in the Western World from ancient civilizations to the first half of the 20th century. We will look at the progression of the shapes and forms that aesthetically define the clothing of each period, while also exploring the broader relationship of costume to culture and society through history. The course will comprise visual presentations of the art of each period, especially pertaining to representations of clothing, along with research projects, quizzes and exams. PRE-REQUISITES: None FOR: All students

54-246 History of Clothing 2

Spring: 6 units

This year-long course surveys the development of garments in the Western World from ancient civilizations to the first half of the 20th century. We will look at the progression of the shapes and forms that aesthetically define the clothing of each period, while also exploring the broader relationship of costume to culture and society through history. The course will comprise visual presentations of the art of each period, especially pertaining to representations of clothing, along with research projects, quizzes and exams. FOR: All students
Prerequisite: 54-245

54-247 Dramaturgy 3: In Company

Intermittent: 9 units

For Dramaturgy majors. Open to non majors with instructor permission.
Prerequisites: 54-109 and 54-184

54-249 Stagecraft II

Fall: 14 units

Stagecraft II presents advanced shop skills and beginning department head skills for Scenery, Lighting, and Costumes. This course will require additional time during the evening and on weekends. Prerequisites: Stagecraft I (two semesters) OR Instructor Permission
Prerequisite: 54-151

54-250 Introduction to Scenic Design

Spring: 6 units

An introduction to the principles and practices of designing scenery emphasizing the interpretation and development of ideas based on a text. Prerequisites: Basic Design, Studiocraft. Drama majors have priority. Non-majors may be allowed in with instructor permission. Prerequisites: 54-169 and 54-171 and 54-172

54-252 Introduction to Lighting Design

Spring: 6 units

Students explore the physical properties of light in various design applications and develop a process of storytelling that involves analysis, research, exploration, questioning, problem solving and implementation of a successful design product. Prerequisite: Design for the Stage, or instructor permission. Prerequisite: 54-231

54-254 New Play Collaboration

Spring: 9 units

For Dramaturgy majors.

54-256 Dramaturgy 4: New Play Dramaturgy

Intermittent: 9 units

For Dramaturgy majors and others with instructor permission.

Prerequisites: 54-109 and 54-184

54-257 Directing: Production II

Fall: 6 units

Assignments as stage manager or assistant director for the Studio and Kresge Theatres.

54-258 Directing: Production II

Spring: 6 units

Assignments as stage manager or assistant director for the Rauh Studio and Chosky Theatres.

54-260 Production Preparation II

Spring

Hands on experience in most aspects of building and running a production. Participation in School of Drama productions, usually on shop fabrication or theatre installation crews. Some participants will fill assistant supervisor positions for other students filling creative or production roles. Prerequisite: Stagecraft II or instructor permission.

54-261 Production Symposium II

Fall: 6 units

Participation in School of Drama productions, usually on shop fabrication or theatre installation crews. Some participants will fill assistant supervisor positions for other students filling creative or production roles. Prerequisites/Co-requisites: Introduction to Production or instructors permission. Prerequisites: 54-159 and 54-160

54-262 Production Symposium II

Spring: 6 units

Participation in School of Drama productions, usually on shop fabrication or theatre installation crews. Some participants will fill assistant supervisor positions for other students filling creative or production roles. Prerequisites: 54-159 or 54-160

54-264 Welding

Fall and Spring: 4 units

An introduction to the four most common metal joining processes, including Oxyfuel processes (welding, brazing, braze welding, and bending), SMAW (stick), GMAW (MIG), and GTAW (TIG). Welding safety, equipment setup and basic welding techniques will be covered. This is a required course for Drama Technical Direction majors. Open to non-majors if space is available.

54-265 Advanced Fabrication

Fall: 6 units

Required for technical direction majors.

54-266 Stage Management: Cue Lab

Fall and Spring: 3 units

Required for Production Management / Stage Management majors

54-267 Conceptual Sound Design 1

Fall: 9 units

Students explore the unique qualities of audio as a design element and the development of a design process through script analysis. Emphasis on the creative application and utilization of the studio in sound shaping and soundscape design. PREREQUISITE: 54-166 Introduction To Sound Design for Theater, 54-231 Design For The Stage. Drama majors have priority, however this course is also open to Music Technology majors and minors, or with permission of instructor.

Prerequisite: 54-166

54-268 Conceptual Sound Design 2

Fall: 9 units

Students explore the unique qualities of audio as a design element. Emphasis on the creative application and utilization of the studio in sound shaping soundscape design. recording techniques, field recording, and mixing. Drama majors have priority, however this course is also open to Music Technology majors and minors, or with permission of instructor. Prerequisites: 54-166 and 54-267

54-269 Studiocraft II

Spring: 3 units

A continuation of 169/170, this course introduces applied drafting practices, perspective drafting, 3D CAD modeling, model building, and other graphical skills. Prerequisites: 54169 and 54170 OR Instructor Permission Prerequisites: 54-171 and 54-172

54-270 Photoshop for the Theatrical Designer

Spring: 3 units

Students will begin the semester by learning the basics of Photoshop and progress by mid-semester to being able to explore the visual theatrical design process through Photoshop, in scenery, lighting and costumes, in conjunction with other methods of image creation. During the second half of the semester, students will learn the basics of Dreamweaver and website creation, with each student producing and publishing a professional website. Registration for this course is limited to Drama students only. Prerequisite: 54-231

54-271 Technical Management

Fall: 6 units

Required for all sophomore Design and PTM students. This class establishes a set of standards for creative project management and introduces students to several software packages that can be utilized within these tasks.

54-272 Scenic Fabrication and Installation

Spring: 6 units

The Scenic Fabrication & Installation course consolidates and builds upon material presented in the first semester of Basic PTM and in the three semesters of Stagecraft class. Whether they intend to pursue careers as technicians, engineers, or managers students must understand how scenery is built and what is involved in the assembly of the scenery in the theatre. Throughout the semester students will explore the materials and equipment used by all kinds of professionals in the fabrication industry. Through this exploration students will become conversant with the kinds of properties, and the advantages and disadvantages of many different items. Along with this exploration is a concurrent investigation of entertainment industry accidents. This material is valuable in how it contextualizes the kind of work students will be involved in, and helps to drive home the very real consequences of errors pertaining to scenery. In the classroom and in lab students in this course will develop their knowledge and processes for building scenery. The course has three basic units. The beginning of the semester focuses on building materials and on tool use. Through the center of the semester course material focuses on traditional scenery practices. The end of the semester material addresses rigging systems and scenery rigging practices. Laboratory assignments tied to this course will consist of carpentry assignments in the shop and carpentry and rigging assignments during load in. Occasionally students pursuing a more customized path may have lab assignments in the paint department in the shop and in the electric department during install. All students may receive apprentice assignments in the scenery office.

54-273 Technical Direction I

Fall: 6 units

6-21 units This course is an exploration of techniques and practices of the Technical Director. The class has three main components: classroom presentation of School of Drama production technical direction process, classroom lectures centering on TD process, and project work. Over the course of the semester, students will work on two productions as paper projects. This is an opportunity to have a somewhat less stressful pass through a show, completing estimates, schedules, and drawings designed to help establish a professional foundation for the student as a technical director. All of the course components run concurrently. Prerequisites: 54272 or Instructor Permission
Prerequisites: 54-158 or 54-272

54-274 Seminar in Costume Management

Fall: 3 units

This mini course focuses on the fundamentals of organizational paperwork surrounding costume production and basic operational protocol. The evolution of this paperwork and its usefulness in multiple professional applications is covered.

54-275 History of Sound Design

Intermittent: 6 units

The history of the use of sound in theater from the Greeks to current day including study of the development of the art, significant practitioners and landmark productions.

54-277 Negotiation and Conflict Management

Fall: 3 units

TBD

54-278 Stage Management I

Spring: 6 units

This class introduces the student to the work of a stage manager on a theatrical production. Students learn the functions and responsibilities of the stage manager. Also covered: blocking notation, cue organization, rehearsal reports and AEA rules and regulations.

54-280 Media Foundations

Spring: 6 units

This course is designed to augment the theoretical background and technical skills of First year Graduate students and newly declared VMD Sophomores. The course reviews foundational readings about media, technology and society and explores the skills used in contemporary media work. Through readings, discussions and workshops (some lead by visiting experts) the class will give students a clearer perspective of the field and help them plan a fulfilling course of study, based on their goals and interests. Class projects range from presentations of research to building media installations over at Studio 201.

54-281 Foundations of Drama II

Fall: 6 units

In this course students build on the skills of Foundations I to develop acumen in targeted research in support of production. The students learn the "circles of knowledge" technique to provide evidentiary arguments concerning a play script, its author, the historical contexts in which it was written, the theoretical frameworks that may be applied to its interpretations, its production history, and what knowledge is needed to bring its themes to relevance in a modern production. As in Foundations I, there is a great deal of exposure to significant texts, both artistic and philosophical, from theatre history. Registration for this course is limited to Drama majors. All other majors must request the instructor's permission.
Prerequisites: 54-177 or 54-178

54-282 Foundations of Drama II

Spring: 6 units

In this course students build on the skills of Foundations I to develop acumen in targeted research in support of production. The students learn the "circles of knowledge" technique to provide evidentiary arguments concerning a play script, its author, the historical contexts in which it was written, the theoretical frameworks that may be applied to its interpretations, its production history, and what knowledge is needed to bring its themes to relevance in a modern production. As in Foundations I, there is a great deal of exposure to significant texts, both artistic and philosophical, from theatre history. Registration for this course is limited to Drama majors and minors.
Prerequisites: 54-177 or 54-178

54-284 Fundamentals of Directing

Fall: 6 units

Fundamentals of Directing is a fall-semester course for Drama Design, Dramaturgy, and PTM sophomores. It is an introductory course that examines some of the basic tools of the director. Emphasis is completely on theatrical work although some elements are applicable to television and film.

54-285 Alexander Technique

Fall and Spring: 1.5 units

Required Alexander work for Senior Acting and Music Theatre majors.
Prerequisites: 54-301 and 54-302

54-291 Speech and Phonetics Instruction and Outreach I

Fall: 6 units

This course is designed for mentors to teach children at the 5th grade level to speak in a clear, efficient and pleasing manner with self-confidence. The children will also be able to understand the relationship between sound and speech; realize the differences between American English speech and spelling; relate symbols of IPA to phonemes we use in speech; improve their articulation of Vowels, Consonants and Diphthongs; discover the musical patterns their voices can make; follow directions and drills to learn to discriminate between correct and incorrect productions of Vowels, Consonants and Diphthongs; develop the techniques for memorization of challenging poetry.

54-292 Speech and Phonetics Instruction and Outreach II

Spring: 6 units

This course is designed for mentors to teach children at the 5th grade level to speak in a clear, efficient and pleasing manner with self-confidence. The children will also be able to understand the relationship between sound and speech; realize the differences between American English speech and spelling; relate symbols of IPA to phonemes we use in speech; improve their articulation of Vowels, Consonants and Diphthongs; discover the musical patterns their voices can make; follow directions and drills to learn to discriminate between correct and incorrect productions of Vowels, Consonants and Diphthongs; develop the techniques for memorization of challenging poetry and participate in a presentation for family and friends using the skills they have learned.

54-294 Make-Up for Performers

Spring: 2 units

PREREQUISITE: Acting/MT major in the School of Drama. Basic techniques of stage make-up and their adaptation to theatrical styles.
Prerequisite: 54-102

54-299 Dramaturgy Production: Practical Observation

Fall and Spring

For Dramaturgy majors.

54-301 Acting III

Fall: 10 units

This is a two-semester course in Acting for Third-Year Actors & MTs who will explore performance within directed structure in various non-Fourth-Wall forms of Theatre including: Greek Tragedy, the Greek Chorus, Moliere Comedy & Brecht. This is not a course that will aspire to provide any "correct" way to play various "styles". Rather, it is a course in which to acquire new tools & perspectives when working in new theatrical worlds. Goals include: to find the appropriate level of external expression to meet the demands of the particular text & its directed world, & to "fill the Form" believably & passionately; to make active choices within a directed framework; to learn to work within industry standards; to learn the nature of the actor's "homework" in a directed framework; to include the Audience in the work.
Prerequisites: 54-201 and 54-202

54-302 Acting III

Spring: 10 units

This is a two-semester course in Acting for Third-Year Actors & MTs who will explore performance within directed structure in various non-Fourth-Wall forms of Theatre including: Greek Tragedy, the Greek Chorus, Moliere Comedy & Brecht. This is not a course that will aspire to provide any "correct" way to play various "styles". Rather, it is a course in which to acquire new tools & perspectives when working in new theatrical worlds. Goals include: to find the appropriate level of external expression to meet the demands of the particular text & its directed world, & to "fill the Form" believably & passionately; to make active choices within a directed framework; to learn to work within industry standards; to learn the nature of the actor's "homework" in a directed framework; to include the Audience in the work.
Prerequisite: 54-301

54-303 Dialects for the Stage

Fall: 6 units

(Voice) The actors continue to strengthen their vocal techniques with voice classes, which become specific in their purpose and require the students to become responsible for their own preparation process. The class also focuses on particular performance challenges in private tutorial work. (Dialects & Accents) Dialects and accents class meets twice weekly in order to build a repertoire of ten American, British, Irish dialects and/or European accents. Each actor also develops an independent project in order to discover a process of research for additional dialects he/she may encounter in the professional world.

Prerequisites: 54-203 and 54-204

54-304 Dialects for the Stage

Spring: 6 units

(Voice) The actors continue to strengthen their vocal techniques with voice classes, which become specific in their purpose and require the students to become responsible for their own preparation process. The class also focuses on particular performance challenges in private tutorial work. (Dialects & Accents) Dialects and accents class meets twice weekly in order to build a repertoire of ten American, British, Irish dialects and/or European accents. Each actor also develops an independent project in order to discover a process of research for additional dialects he/she may encounter in the professional world.

Prerequisites: 54-203 and 54-204

54-305 Voice/Alexander III

Fall: 5 units

Students explore voice work and various methods in more depth and Alexander alignment/awareness work to enhance vocal freedom and full body support of the voice. Areas include: breath support, vocal release, developing freedom in resonating areas, clarity in articulators, building range and stamina. Emphasis is placed on integration of methods with speaking of text. Writing projects are sometimes explored as a way to free the voice creatively and imaginatively. Voice/Alexander I is a pre-requisite to registering in this course.

Prerequisites: 54-105 and 54-106

54-306 Voice/Alexander III

Spring: 5 units

Students explore voice work and various methods in more depth and Alexander alignment/awareness work to enhance vocal freedom and full body support of the voice. Areas include: breath support, vocal release, developing freedom in resonating areas, clarity in articulators, building range and stamina. Emphasis is placed on integration of methods with speaking of text. Writing projects are sometimes explored as a way to free the voice creatively and imaginatively. Voice/Alexander I is a pre-requisite to registering in this course.

Prerequisites: 54-105 and 54-106 and 54-305

54-307 Movement III

Fall: 5 units

Prerequisite: 54-107, 54-108, 54-207, 54-208, or permission of the instructor. This course introduces students to the basic exercises of physical actor training developed by Tadashi Suzuki and examines more advanced uses of the Viewpoints method of actor training. Physically rigorous, this course challenges not only physical stamina, but also concentration, focus and the actor's sense of discipline. The use of spoken text is incorporated into the exercises in an integration of all the physical aspects of the actor's craft. This course is also designed to complement and inform the actor's entry into rehearsal and performance work. This course is required for all third year Acting majors.

Prerequisites: 54-207 and 54-208

54-308 Movement III

Spring: 5 units

Prerequisite: 54-307, or permission of the instructor This course focuses on the art of stage combat. Basic techniques of unarmed stage violence are studied and an introduction to other weapons such as knife and/or single rapier may be included. Emphasis is placed not only on technique, but the acting of scenes of violence found in both classical and contemporary plays. This is a required course for all third year Acting majors.

Prerequisites: 54-207 and 54-208

54-309 Accents for the Stage

Fall: 6 units

This is a two-semester class which teaches the collaborative process of theatre — including the role of the living dramatic writer. New scripts are written by graduate dramatic writers, then developed and realized by junior actors, senior dramaturgs, graduate and undergraduate directors, with the playwright. This work results in 10-minute play scripts, one acts, monologue dramas, and the texts for the MFA Thesis Productions. This class is co-taught by the Acting, Dramatic Writing, Dramaturgy, and Directing Options.

54-310 Accents for the Stage

Spring: 6 units

This is a two-semester class which teaches the collaborative process of theatre — including the role of the living dramatic writer. New scripts are written by graduate dramatic writers, then developed and realized by junior actors, senior dramaturgs, graduate and undergraduate directors, with the playwright. This class is co-taught by the Acting, Dramatic Writing, Dramaturgy, and Directing Options.

54-311 Rehearsal and Performance III

Fall: 16 units

Performance training through projects at different levels of difficulty and staging, directed by students and presented in the studio theatre. The actor has the opportunity to put into practice with his/her peers, in a creative and experimental atmosphere, the principles and techniques developed in the classroom.

Prerequisites: 54-201 and 54-202

54-312 Rehearsal and Performance III

Spring: 16 units

Performance training through projects at different levels of difficulty and staging, directed by students and presented in the studio theatre. The actor has the opportunity to put into practice with his/her peers, in a creative and experimental atmosphere, the principles and techniques developed in the classroom.

Prerequisites: 54-201 and 54-202

54-313 Ballet III

Fall: 3 units

This course is dedicated to honing technical skills, expanding the classical dance vocabulary to the next level of difficulty, and addressing issues of strength, stamina, and endurance. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor

Prerequisites: 54-205 and 54-206

54-314 Ballet III

Spring: 3 units

This course continues to hone technical skills, expand the classical dance vocabulary to the next level of difficulty, and address issues of strength, stamina, and endurance. Course closed: Only for Music Theatre majors in Drama. Prerequisite: 54-313 and Permission of instructor

Prerequisite: 54-313

54-315 Jazz III

Fall: 2 units

This course is to expand the versatility of the student dancer to master more complex exercises, in dynamics, direction and rhythm using Jazz styles examined by decades. Understanding the 20th century historical background of the 20's, 30's 40's, 50's 60's and 70's. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor

Prerequisites: 54-217 and 54-218

54-316 Jazz III

Spring: 2 units

This course continues to expand the versatility of the student dancer to master more complex exercises, in dynamics, direction and rhythm using Jazz styles examined by decades. Understanding the 20th century historical background of the 20's, 30's 40's, 50's 60's and 70's. Course closed: Only for Music Theatre majors in Drama.

54-317 Singing for Actors III

Fall: 2 units

The students have a class voice experience which includes a physical and vocal warm-up and discussion and practice of healthy singing technique. There is group and individual rehearsal of potential audition and performance material. Toward the end of the term, there are weekly opportunities to perform in public, thus preparing for auditions.

Prerequisites: 54-201 and 54-202

54-318 Singing for Actors III

Spring: 2 units

The students have a class voice experience which includes a physical and vocal warm-up and discussion and practice of healthy singing technique. There is group and individual rehearsal of potential audition and performance material. Toward the end of the term, there are weekly opportunities to perform in public, thus preparing for auditions.

Prerequisites: 54-201 and 54-202

54-319 Cabaret

Fall: 6 units

The Art of Cabaret: Explores the use of Stories and Song to communicate life experiences within an intimate setting, breaking down the invisible fourth wall for honest communication. The course includes a section on the use of the microphone for singers. This Study produces two Cabarets containing Material on a chosen Theme to provide hands-on Song Expression in a public forum.

Prerequisite: 54-220

54-321 Acting III for Directors

Fall: 9 units

An examination of various directing styles with particular attention to: verse forms including Greek and Elizabethan, comedy/ farce texts and Early 20th century styles including Ibsen and Shaw. On occasion, guest directors for our main-stage productions will be engaged to teach the style of the production that they are presently working on. Alternately, there is the possibility of this semester being used for an applied internship with a major producing organization.

Prerequisites: 54-101 and 54-201

54-322 Directing III: Future Stages

Fall: 6 units

FUTURE STAGES combines options from the School of Drama in a new configuration: through working collaboratively across disciplines, students investigate multimedia approaches to contemporary theater and new ways of storytelling. Directors, designers, actors, and dramaturgs work in groups to generate original ideas, images, texts, and material in a workshop environment. These working groups create projects over the course of the semester which are shown in informal presentations. The emphasis is on process, not product — devising an interdisciplinary performance requires a keen focus on combining creative invention with a rigorous structure of concept development — both of which are explored here. We also examine the work of several significant contemporary theater artists whose work approaches collaboration across a variety of disciplines. Artists have included: Ariane Mnouchkine, Dumbtype, Complicite, Ralph Lemon, Robert LePage, and more. Students learn to define and distinguish these artist's approaches through viewing video excerpts, readings, and discussion. This class is an opportunity to explore avenues outside of traditional production modes and beyond each student's individual discipline. We focus on the process of creating a theatrical language which truly integrates disciplines.

54-323 Tap III

Fall: 2 units

This course expands tap vocabulary and clear precision of execution through moderately difficult and extended combinations. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor

Prerequisites: 54-223 and 54-224

54-324 Tap III

Spring: 2 units

This course continues to expand tap vocabulary and clear precision of execution through moderately difficult and extended combinations. Course closed: Only for Music Theatre majors in Drama. Prerequisite: 54-323 and Permission of instructor

Prerequisite: 54-323

54-325 Actor Dance III

Fall: 2 units

This course uses basic and fundamental contemporary Jazz styles, i.e. Latin, Blues, Lyric, African, to technically train the body using isolations and rhythmic patterns. Course closed: Only for Acting majors in Drama.

Prerequisite: Permission of instructor

Prerequisites: 54-201 and 54-202

54-326 Actor Dance III

Spring: 2 units

This course continues to use basic and fundamental contemporary Jazz styles, i.e. Latin, Blues, Lyric, African, to technically train the body using isolations and rhythmic patterns. Course closed: Only for Acting majors in Drama. Prerequisite: 54-325 and Permission of instructor

Prerequisites: 54-201 and 54-202

54-327 Junior Auditioning

Fall: 2 units

An optional course for Junior Acting and Music Theatre majors.

Prerequisite: 54-202

54-328 Advanced Digital Sound Design Skills

Fall: 6 units

Advanced sound creation and manipulation through student designed and constructed software and hardware. Prerequisite: Conceptual Sound Design I or permission of instructor.

Prerequisites: 54-267 or 54-867

54-330 Introduction to Stage Management

Spring: 6 units

This course is intended to provide students an opening to the knowledge and skills of the professional stage manager. It will also illuminate the qualities of a good stage manager specific to personality and human interaction. Within this course we will examine the role of the stage manager throughout the full scope of creating a production, including preparatory work, rehearsal period, technical rehearsal, performance and closing.

54-331 Scenic Design: Explorations

Fall: 9 units

Students will spend the year in an exciting and intensive exploration of the process of Scene Design as well as an examination of the nature of creativity and storytelling. Students will also engage extensively in the skills a professional Scene Designer requires, such as drafting, drawing, model making, painting and general collaborative skills. Students will be expected to deal with in-depth research, scriptural examinations, careful arrangements of space, composition and groundplan, conceptual structure, real life obstacles and the elements of a successful final project. By the end of this course, students will have improved their overall design skills, have some projects they can include in their portfolio and have created new routes toward their creativity. (pre-req, intro to Scene Design)

54-332 Scenic Design: Boot Camp

Spring: 9 units

A rapid-fire design course for scenic design majors. This course offers the students the opportunity to work on six projects over the course of the semester. These projects may include contemporary, classical and non-linear plays, as well as TV workshop and a new plays collaboration with dramatic writing students. Co-taught by Scenic Design faculty.

Prerequisite: 54-250

54-333 Production Personnel Management

Fall: 6 units

Study of the management of production personnel for live theatrical productions. In depth analysis of union contracts from a management perspective: AEA, IATSE, USA. Projects in scheduling and budgeting based on those contracts. Study of hiring, evaluating, and retaining a quality staff. Examination of the role of safety protocols in production. The Course concentrates on the relationship between the Production Manager and all of the personnel that one comes in contact with.

54-334 Production Resource Management

Spring: 6 units

This course examines the management of resources for the production of live theatrical productions. We start with analysis of scripts, to find the foundation for resource allocation. Then we move on to study the allocating two of the largest production resources: time and money. A significant exploration of the tracking of time and money extends throughout the course, with half of the class sessions taking place in a computer cluster, where we concentrate on advanced application of Excel, Access, and specialized calendar software.

54-337 Scenic Painting 2

Fall: 4 units

tba

Prerequisites: 54-237 or 54-238

54-338 Scenic Painting 2

Fall: 6 units

This is a year long course designed to explore more complex scene painting problems with an emphasis on professional standards. Projects in the first semester will address such topics as: translucency, tromp l'oeil, aging techniques, signage, perspective, and working 3 dimensionally. Adequate mastery of skills in the first semester will permit more freedom in the second semester to do independent projects or group projects for public display.

Prerequisites: 54-237 and 54-238 and 54-337

54-339 Stage Management Seminar

Fall: 3 units

This class provides stage managers an opportunity to participate in in-depth discussion about the production process. Specific issues related to CMU productions and troubleshooting problems are a particular focus. The class also presents guest speakers on related topics and will work on longer-term projects as needed.

54-340 Stage Management Seminar

Spring: 3 units

This class provides stage managers an opportunity to participate in in-depth discussion about the production process. Specific issues related to CMU productions and troubleshooting problems are a particular focus. The class also presents guest speakers on related topics and will work on longer-term projects as needed.

54-341 Fundamentals of Costume Design

Fall: 9 units

Multiple studio projects comprise this one semester course that focuses on the principals and elements of design, including color theory, as they relate to Costume Design. Hands-on practical workshops include a Television Workshop component with celebrated CMU alumni, and a dance component that culminates in the second semester Dance/Light Concert. A fabric Identification component rounds out the semester. PRE-REQUISITE: Declared Costume Design Major in School of Drama. All others: Portfolio Review and special permission of teacher required. Drawing For The Theatrical Designer & Figure Drawing may be taken concurrently. FOR: First semester Graduate Costume Design and Costume Production Students, First semester Junior Costume Majors.

54-342 Costume Design for TV and Film

Spring: 9 units

A full semester course in the second semester that explores the aesthetic and technical processes of designing costumes for the screen. The course introduces film-specific practical skills including the fundamentals of analyzing and breaking down screenplays for costume design, what design means during the pre-production and shooting phases of a production, and the aesthetic and technical differences of designing for the camera's eye compared to designing for the human eye. The course will consist of lectures, visual presentations, including viewing of films that illustrate the processes described in class, script break-down assignments, and design process projects. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: Second year Graduate Costume Design majors and Senior Costume Design students.

54-343 Costume Construction I

Fall

FOR: Drama sophomores and juniors. This hands on practical application course is a study of primary construction principals with emphasis on the development of patterns from the basic costume shapes through history. Primary shapes first semester include men's and women's multi-piece bodices, historic sleeve shapes, breeches and skirts. The ability to look at a picture and interpret it to create the shape in fabric is stressed. Second semester, draping, boots and millinery are explored with some garments patterned for departmental productions. Techniques for communicating with the designer and fitting the actor are developed.

54-344 Costume Construction I

Spring: 6 units

FOR: Drama sophomores and juniors. This hands on practical application course is a study of primary construction principals with emphasis on the development of patterns from the basic costume shapes through history. Primary shapes first semester include men's and women's multi-piece bodices, historic sleeve shapes, breeches and skirts. The ability to look at a picture and interpret it to create the shape in fabric is stressed. Second semester, draping, boots and millinery are explored with some garments patterned for departmental productions. Techniques for communicating with the designer and fitting the actor are developed.

54-346 Introduction to Costume Construction

Spring: 6 units

This sophomore level course is designed to provide an intermediate level of training in the area of clothing construction. Students learn how to read patterns, prepare and cut fabric appropriately for construction purposes, and complete a garment employing necessary finishing techniques. Basic flat-pattern and tailoring techniques are also explored.

54-347 Figure Drawing

Fall: 4 units

Enrollment priority is given to Costume Design majors, then Design majors. This course will explore the realistic and expressive depiction of the human form. Students will work from live models each week, addressing such topics as anatomy and structure, gesture and movement, proportion and composition and individual expression. A variety of 2-dimensional media will be explored, as well. This course is designed to give students a solid grounding in their understanding of the human form and to increase their facility and confidence in drawing it accurately and expressively.

54-348 Figure Drawing

Spring: 4 units

Enrollment priority is given to Costume Design majors, then Design majors. This course explores the realistic and expressive depiction of the human form, primarily in two dimensional media. Students will work from nude, draped and clothed live models, and will explore various media and formal approaches to the figure. A primary goal of the class is to develop the ability to create the human figure from imagination, based on intensive empirical study of the forms and structures of the human body from life. Although most of the work takes place in class, some outside study is required.

54-349 Automated Lighting Technology

Spring: 6 units

Students are exposed to a range of automated lighting equipment and develop skills in the implementation of them in a production situation. Programming of automated fixtures on a variety of consoles is emphasized. Prerequisites: 54-351
Prerequisites: 54-351 and 54-352

54-350 Introduction to Media Design

Spring: 9 units

Students become familiar with pre-visualization software programs as a tool for problem solving design issues and communicating design intent. Programs may include WYSIWYG, Visionary, ESP Vision and Martin Show Designer. Prerequisite: 54-252

54-351 Theatrical Lighting Design

Fall: 9 units

The student's ability to analyze and translate information in the script to descriptive stage pictures is developed in a more in-depth process. Verbal, written and visual communication of ideas is emphasized and explored through texts and lab work. Issues of collaboration with the director and other members of the design team are discussed as part of the design process. Prerequisites: 54252
Prerequisite: 54-252

54-352 Theatrical and Opera Lighting Design

Spring: 4 units

tba
Prerequisite: 54-351**54-353 Structural Design I**

Fall: 9 units

Required for all senior undergraduate Technical Direction students. A concentrated training in Structural Design specifically developed for the theater technician. This course teaches the process of Allowable Stress Design for the engineering of scenic structures in wood and steel. Drama majors only, or with instructor permission.

54-354 Structural Design II

Spring: 9 units

Required for all senior undergraduate Technical Direction students. Upon completion of this two-semester sequence, students are familiar with beam and column design/specification, truss design, tensile systems and structural connections. Prerequisite: 54-353

54-355 30 Hour OSHA

Intermittent: 6 units

For Production Technology & Management majors.

54-356 Stage Management TV Project

Fall: 3 units

Missing Course Description - please contact the teaching department.

54-357 Directing: Production III

Fall: 12 units

Assignments as stage manager or assistant director for the Studio and Kresge Theatres.

54-358 Directing: Production III

Spring: 12 units

Assignments as stage manager or assistant director for the Rauh Studio and Chosky Theatres.

54-359 Stage Management and Actors Equity

Fall: 3 units

This class provides an in-depth exploration of Actors Equity Association and work rules for actors and stage managers. Through careful reading of contracts and guidelines, we will gain an understanding of current practice and the stage manager's place within it. The class will also study related unions and current issues affecting the theatre.

54-360 Leadership Workshop: Ethics & Innovation

Intermittent: 6 units

For Production Management and Stage Management majors.

54-361 Production Preparation III

Fall

TBA

54-362 Production Preparation III

Spring

Missing Course Description - please contact the teaching department.

54-363 Dramaturgy 5: Devised and Documentary Theatre

All Semesters: 9 units

Missing Course Description - please contact the teaching department.

Prerequisites: 54-109 and 54-184

54-364 Dramaturgy 6: Critical Writing

Intermittent: 9 units

For Dramaturgy majors.

Prerequisite: 54-184

54-365 Machine Design I

Fall: 9 units

Required for all senior undergraduate Technical Direction students. In this course, concepts from Physics of Stage Machinery are applied to the specification, selection, design and assembly of real-world mechanical components for the realization of winches, turntables, wagons and lifts for theatrical use. Drama majors only, or with instructor permission.

Prerequisite: 54-366

54-366 Physics of Stage Machinery

Fall: 9 units

Required for all junior undergraduate PTM students. This is a one-semester pure Physics class designed to give theater technicians a base knowledge of Newtonian Physics, a pre-requisite for later courses in Machine Design. For this course, I have obtained special permission to use an unpublished text by Alan Hendrickson of the Yale University school of Drama. Drama majors only, or instructor permission.

54-367 Lighting Design Skills

Fall: 3 units

Students will concentrate on developing the skills necessary for lighting designers to successfully implement their designs in the theatre. Content includes communication, CAD programs, paperwork, focusing the show, programming conventional and moving light consoles, cue writing and expectations and responsibilities of the design assistant. This class meets during weeks 1-5 of the fall 2011 semester.

54-368 Production Electrics

Spring

Class content includes practical skills in lighting and electrical theory and practice as it pertains to entertainment lighting as well as development of managerial techniques used by Production Electricians in the industry. Students completing the class satisfactorily will be prepared for Master Electrician assignments on School of Drama productions as well as similar positions outside of the School.

Prerequisites: 54-151 or 54-152

54-369 Lighting Design Skills

Spring: 3 units

TBD

54-371 Personalized Responsive Environments

Fall: 9 units

[IDeATe collaborative course] Environmental factors have a significant impact on mood and productivity. Creating responsive environments necessitates the design of surroundings that are able to metamorphose in order to optimize user strengths and available resources and evolve in stride with user needs. This course will investigate the development of spaces that adapt to user preferences, moods, and task specific demands. Both the design and engineering of such personalized environments will be explored. Central course concepts will include, understanding the user, integrating various modalities (e.g., light, heat, sound) to support the changing needs of task and user, and the creation of adaptive environments that learn user preferences over time. Please note that there may be usage/materials fees associated with this course.

Prerequisites: 15-104 or 16-223 or 62-150 or 60-223 or 18-090

54-372 Theatre for the Ear

Spring: 6 units

Survey of aural storytelling with technology focusing on forms with no visual component. Topics include the history of radio drama to present day, radio sound art, cut-up and tape manipulation, comedy records and podcast dramas. Prerequisites: 54-166 Introduction To Sound Design, 54-267 Conceptual Sound Design I Restrictions: The course is open to sound design majors or with permission of the instructor.

54-373 Draping 1

Fall: 6 units

PRE-REQUISITES: Drawing for the Theatrical Designer, Major in Design Option of School of Drama FOR: Graduate and Undergraduate Design Costume Majors only. Instructor Approval required. DESCRIPTION: this fast-paced course focuses on techniques and exercises specific to the development of refined and versatile costume renderings. A variety of mediums and methods are explored including colored pencil, marker, ink, Doctor Martin's dyes, watercolor and acrylic as well as transfer drawings, resists and the use of other techniques. Color, texture, pattern and clothed human models are carefully studied and rendered. Students also apply course techniques to development of designs for production and portfolio preparation.

54-375 Robotics for Creative Practice

Fall: 10 units

[IDeATe collaborative course] This project-oriented course brings art and engineering together into making machines which are surprisingly animate. Students will iterate their concepts through several small projects focused on using embodied behavior as a creative medium for storytelling, performance, and human interaction. Students will learn skills for designing, constructing and programming simple robot systems, then exploring their results through exhibition and performance. Technical topics include systems thinking, dynamic physical and computational behavior, autonomy, embedded programming, and fabrication and deployment. Discussion topics include both contemporary kinetic sculpture and robotics research. Please note that there may be usage/materials fees associated with this course.

Prerequisites: 62-150 or 60-223 or 16-223 or 15-104

54-376 Entertainment Rigging

Spring: 3 units

This course is a survey of the techniques and practices of theatrical rigging. The course has two main components: permanently installed rigging systems typically found in theatres, and background and technical information concerning the components typically used for stage rigging. Discussion topics include selection criteria for line, hardware, and terminations stressing entertainment industry standards, workplace safety and common industry misconceptions. Time permitting the course will shift from a general discussion of components to their assembly into custom rigging systems & solutions. Instructor's permission only.

Prerequisite: 54-477

54-378 Technical Direction II

Spring: 6 units

This course is an exploration of techniques and practices of Technical Designers. The class has four main components: an exploration of the types of strategies used by Technical Designers to arrive at solutions, building an expert vocabulary for discussion of technical design issues, development of actual technical solutions, on paper, in discussion, and in the shop, discussion of any pertinent technical issues for any of the school productions while in development.

Prerequisite: 54-273

54-379 Scenic Design Skills: Drafting

Fall: 4 units

This mini explores careful and clear graphic communication in drafting. A series of weekly drafting exercise, either hand or CAD, take each student through the process of drafting a scenic design. Emphasis is placed on precision, clarity, and appropriate use of standard drafting conventions.

54-380 Music Reading for Drama Technicians

Spring: 3 units

This class gives the basics of music theory, musical terminology and score reading. Students focus on the difference in various musical scores, ie. piano/vocal, full, hand written scores. Students are guided in classroom listening which a wide variety of music including, opera, musical theatre, ballet, and choral/orchestra works.

54-381 Special Topics in Drama: History, Literature and Criticism

Fall and Spring: 6 units

Every semester, members of the School of Drama's faculty offer seminars on special topics that investigate some aspect of theatre history, dramatic literature, dramatic theory, or a particular author, period, or genre. Like all Dramatic Literature classes, these are academically rigorous, requiring some amount of intensive critical reading and writing. Registration for this course is limited to Drama majors.

54-382 History of Drama

Fall and Spring: 3 units

Every semester, members of the School of Drama's faculty offer seminars on special topics that investigate some aspect of theatre history, dramatic literature, dramatic theory, or a particular author, period, or genre. Like all Dramatic Literature classes, these are academically rigorous, requiring some amount of intensive critical reading and writing. Registration is limited to Drama majors.

54-383 Scenic Design Skills: Digital Drawing

Fall: 4 units

This mini offers digital drawing and rendering for theatrical designers

54-386 Scenic Design Skills: 3D Model Making

Spring: 4 units

In this mini students explore a variety of three-dimensional media techniques as they learn to build models for the Scenic Designer. Students will investigate many aspects of model-making, from basic structural ideas to complex organic and architectural forms, furniture, and advanced techniques such as scale painting, soldering and carving. Through these methods, students will develop a better understanding of space and objects in space in the theatre.

Prerequisite: 54-231

54-387 Dramaturgy : Production I

Fall

Working as a production dramaturg for a senior thesis or grad show, or as an assistant dramaturg for a season show, in junior year.

54-388 Dramaturgy: Production I

Spring

Working as a production dramaturg for a senior thesis or grad show, or as an assistant dramaturg for a season show, in junior year.

54-389 Composition for Theatrical Sound Design 1

Fall: 6 units

Composition for Theatrical Sound Design 1 This course will concentrate on developing compositional skills for use in theatrical sound design. The full length of this course is designed to take place over two semesters. The 1st semester will examine the building blocks of composition such as rhythm, modes, harmony and counterpoint. The second semester will focus on more advanced skills in composition within a theatrical context. Through projects distributed throughout the semester you will practice the skill-based techniques of music notation, orchestration, synthesis, sequencing, and the creation and utilization of sample-based instruments. This course will also cover textual analysis as it applies to both the inspiration for composition and to the more direct challenge of setting music to text.

54-390 Composition for Theatrical Sound Design 2

Spring: 6 units

This course will concentrate on further developing compositional skills for use in theatrical sound design. The full length of this course is designed to take place over two semesters. This is the second semester and builds on compositional techniques such as writing melody, harmony, counterpoint and orchestration techniques. The second semester focuses particularly on more advanced skills in composition within a theatrical context. Through projects distributed throughout the semester students practice the skill-based techniques of music notation, orchestration, synthesis, sequencing, working with instrumentalists and the creation and utilization of sample-based instruments. This course will also cover textual analysis as it applies to both the inspiration for composition and to the more direct challenge of setting music to text.

54-391 Media Design Skills

Fall and Spring: 3 units

to be determined

54-392 Scenic Design Skills: 2D Drawing and Rendering

Spring: 4 units

This mini offers practice in two-dimensional drawing and rendering for the theatre.

54-393 My True Voice

Fall: 6 units

This course is designed for mentors to teach children at the 5th grade level to speak in a clear, efficient and pleasing manner with self-confidence. The children will also be able to understand the relationship between sound and speech; realize the differences between American English speech and spelling; relate symbols of IPA to phonemes we use in speech; improve their articulation of Vowels, Consonants and Diphthongs; discover the musical patterns their voices can make; follow directions and drills to learn to discriminate between correct and incorrect productions of Vowels, Consonants and Diphthongs; develop the techniques for memorization of challenging poetry.

54-394 My True Voice

Spring: 6 units

This course is designed for mentors to teach children at the 5th grade level to speak in a clear, efficient and pleasing manner with self-confidence. The children will also be able to understand the relationship between sound and speech; realize the differences between American English speech and spelling; relate symbols of IPA to phonemes we use in speech; improve their articulation of Vowels, Consonants and Diphthongs; discover the musical patterns their voices can make; follow directions and drills to learn to discriminate between correct and incorrect productions of Vowels, Consonants and Diphthongs; develop the techniques for memorization of challenging poetry and participate in a presentation for family and friends using the skills they have learned.

54-397 Sound Design For Interactive Environments & Non-Linear Storytelling

Spring: 9 units

This course will examine the process, execution and implementation of sound design for interactive and non-linear storytelling paradigms. Emerging trends in immersive theater, gaming, installation art and multi-media place unique demands on the sound designer both in terms of content and delivery. The student will explore how these demands effect the fundamental processes of design, development of content and flexible delivery systems. Through a combination of directed readings, exploration of current & emerging trends, and project assignments the student will be encouraged to experiment and explore design modes and methodologies that support this flexible method of storytelling.

Prerequisites: 54-268 or 54-267

54-398 Film Sound Design

Spring: 9 units

A one semester course introducing the art of film sound design. Topics include the history of sound design for film, critical theories about cinematic sound design and an introduction to the techniques used especially as they relate to and differ from theatrical sound design. Prerequisites: 54-267 Conceptual Sound Design 1. Restrictions: The course is open to Drama majors, Music Technology majors or by permission of the instructor.

Prerequisites: 54-267 and 54-268

54-399 Decoding Media

Fall: 6 units

The entire theatrical process can be considered as a series of decodings and re-encodings, first decoding the text (by the creative team), re-encoding (the design & direction) and finally decoding by the audience. And the media design process itself requires a sophisticated grasp of multiple layers of encoding and decoding technically, conceptually and experientially. This class is designed to give students a solid foundation in contemporary media design skills while simultaneously providing an examination of the function of theater historically and the ways media technologies fill those needs today. Early assignments focus on students' use of media in their everyday lives, by keeping media journals and bringing in media objects for examination. Later classes focus on taking ideas from this research and applying them in conceptual stage designs for an early Greek play, a contemporary adaptation and then a play of the students choosing. The class covers technical and conceptual basics from text analysis, research, storyboarding and analyzing dramatic structure to understanding screen/surface characteristics; video cue building; projection optics; and creating projection plots and other tools for communication with team members. Class assignments focus on the creation of dramatically relevant media-worlds and communicating these design ideas verbally, visually and in written documentation.

54-400 Staging Media

Spring: 6 units

Staging Media is a practical, process-oriented class, focused on building the skills to go from a conceptual design to an actual completed show. The course covers 3 major topics; media workflow, media system design and media staging. Through real-world examples, conceptual design projects, and hands-on lab work students will learn the best practices for bringing their designs to life. A great deal of technical information will be covered including; video compression formats, projector optics, cueing software, projection mapping & custom surfaces, media servers both custom and professional, networking and control, live camera systems, and stage rigging for projection systems.

54-401 Camera Lab

Fall: 3 units

This is a year long course required for senior undergraduate directing and acting majors and second year graduate directors. The students are introduced to some fundamental ideas about story telling with a camera. The students learn and practice both single and multi-camera techniques. There are a series of projects for the students to encounter and practice acting, directing, and designing for the camera.
Prerequisite: 54-302

54-402 Camera Lab

Spring: 3 units

This is a year long course required for senior undergraduate directing and acting majors and second year graduate directors. The students are introduced to some fundamental ideas about story telling with a camera. The students learn and practice both single and multi-camera techniques. There are a series of projects for the students to encounter and practice acting, directing, and designing for the camera.

54-403 Voice Over Acting

Fall: 3 units

(Voice) The senior actors continue to strengthen their voice work with individualized voice classes and tutorials. The voice work often addresses particular issues, which these actors encounter in the mainstage productions. Students also re-visit classical text work and build on their sophomore year preparation with additional Shakespeare material. The pieces are prepared as professional audition selections in this work. (Voice-Over Acting) A commercial aspect of the voice work is introduced, developed and marketed in the Voice-Over Acting class. The course presents information which is then applied to narrating radio and television commercials, industrials, feature-length animations, books on tape, CD-ROM videos, computer software programs, etc. Texts are developed for two demo tapes, which are prepared in class and readied for a professional studio-taping session.

54-404 Voice Over Acting

Spring: 6 units

(Voice) The senior actors continue to strengthen their voice work with individualized voice classes and tutorials. The voice work often addresses particular issues, which these actors encounter in the mainstage productions. Students also re-visit classical text work and build on their sophomore year preparation with additional Shakespeare material. The pieces are prepared as professional audition selections in this work. (Voice-Over Acting) A commercial aspect of the voice work is introduced, developed and marketed in the Voice-Over Acting class. The course presents information which is then applied to narrating radio and television commercials, industrials, feature-length animations, books on tape, CD-ROM videos, computer software programs, etc. Texts are developed for two demo tapes, which are prepared in class and readied for a professional studio-taping session.

54-405 Undergraduate Future Stages

Fall: 6 units

FUTURE STAGES combines options from the School of Drama in a new configuration: through working collaboratively across disciplines, students investigate multimedia approaches to contemporary theater and new ways of storytelling. Directors, designers, actors, and dramaturgs work in groups to generate original ideas, images, texts, and material in a workshop environment. These working groups create projects over the course of the semester which are shown in informal presentations. The emphasis is on process, not product — devising an interdisciplinary performance requires a keen focus on combining creative invention with a rigorous structure of concept development — both of which are explored here. We also examine the work of several significant contemporary theater artists whose work approaches collaboration across a variety of disciplines. Artists have included: Ariane Mnouchkine, Dumbtype, Complicite, Ralph Lemon, Robert LePage, and more. Students learn to define and distinguish these artist's approaches through viewing video excerpts, readings, and discussion. This class is an opportunity to explore avenues outside of traditional production modes and beyond each student's individual discipline. We focus on the process of creating a theatrical language which truly integrates disciplines.

54-407 Movement IV

Fall: 4 units

Movement IV is a cross-option course, wherein Sophomore Designers build masks for the Senior Actors to use in the creation of a movement mask piece based on a classic text. The course gives Senior Actors an opportunity to create an original ensemble performance piece, bringing up to 30 masks to life, using skills learned in the previous classes in mask work (Neutral Mask, Commedia dell'Arte, character and larval masks). Due to the necessity of working as an ensemble in the creation of this piece, the students must work together in various roles: as actors, of course, but also as directors, writers, musicians, dramaturges and stage managers; this course offers a rare chance for students to experiment with actor-created theatre, as well as, because it is cross-option, an opportunity for actors and designers to work together to create masks which are able to be brought to life through movement, that are comfortable, offer enough visibility, are secure during activity, etc. A unique learning laboratory for designers and actors to interact involving both artistic and practical issues related to the creation and use of these masks as theatrical metaphor. Limited to Senior Actors/MTs.

Prerequisites: 54-207 and 54-208

54-408 Movement IV

Spring: 4 units

In the Senior year, students may study stage combat, including hand-to-hand, quarterstaff, and single rapier, leading to scene work incorporating these skills. Other studies might include dramatic acrobatics, circus skills, and Eastern disciplines such as yoga, Tai Chi, etc. Focus on personal physical style; application of movement training on the mainstage in performance.

Prerequisites: 54-207 and 54-208

54-409 Theatre Lab for Undergraduates

Fall

This is a two-semester class which teaches the collaborative process of theatre — including the role of the living dramatic writer. New scripts are written by graduate dramatic writers, then developed and realized by senior actors, senior dramaturgs graduate and undergraduate directors with the playwright. This work results in 10-minute play scripts, one acts, monologue dramas, and the texts for the MFA Thesis Productions. This class is co-taught by the Acting Dramatic Writing, Dramaturgy and Directing Options.

54-410 Theatre Lab for Undergraduates

Spring

Theatre Lab is a place to practice collaboration. We will examine and explore the relationships between actor, director, and playwright in working on new plays. The objectives are to prepare students to work collaboratively on new play production as it is practiced in the field, to understand the responsibilities of actor, director, and playwright in work on a new text, and to practice being an outstanding collaborator.

54-411 Rehearsal and Performance IV

Fall: 16 units

Participation outside of class requirements in departmental productions. Putting into practice the techniques acquired over the years of training and exploring the development of a performance played before the public over two weeks.

Prerequisites: 54-311 and 54-312

54-412 Rehearsal and Performance IV

Spring: 16 units

Participation outside of class requirements in departmental productions. Putting into practice the techniques acquired over the years of training and exploring the development of a performance played before the public over two weeks.

Prerequisites: 54-311 and 54-312

54-413 Showcase

Fall: 4 units

Senior acting class for actors and Mt's who are in good standing and in position to graduate in the Spring. Preparation for the New York and Los Angeles Showcase presentations.

Prerequisites: 54-301 and 54-302

54-414 Showcase

Spring: 9 units

Senior acting class for actors and Mt's who are in good standing and in position to graduate in the Spring. Preparation for the New York and Los Angeles Showcase presentations.

Prerequisites: 54-301 and 54-302

54-415 Broadway Dance Styles

Fall: 5 units

This course is designed to provide the student with a practical and historical knowledge of the dance repertoire in American Musical Theater using the original choreography from prominent Broadway choreographers. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor

Prerequisite: 54-319

54-416 Broadway Styles

Spring: 5 units

This course continues to provide the student with a practical and historical knowledge of the dance repertoire in American Musical Theater using the original choreography from prominent Broadway choreographers. Course closed: Only for Music Theatre majors in Drama.

Prerequisite: 54-319

54-419 Voice & Speech IV

Fall: 3 units

For Senior Acting majors only.

54-420 STAGE COMBAT

Fall: 4 units

TBA

54-421 Directing: Text to Stage

Fall: 3 units

TBD

54-422 Directing IV

Spring: 6 units

Encounter major 20th century theatrical and dramatic movements. Specific concentration on directorial innovations in the last half of the 20th century

54-423 Tap IV

Fall: 2 units

This course presents advance tap vocabulary and challenges the ability of the student to master advanced repertoire at a consistent professional level. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor

Prerequisites: 54-324 and 54-323

54-424 Tap IV

Spring: 2 units

The course continues to presents advance tap vocabulary and challenges the ability of the student to master advanced repertoire at a consistent professional level. Course closed: Only for Music Theatre majors in Drama.

Prerequisite: 54-423 and Permission of instructor

Prerequisite: 54-423

54-431 Scenography

Fall: 9 units

A core design class between scenic designers, costume designers, media designers, and directors collaborating to create projects on paper. This class allows students to experiment away from the pressure of a realized production. The course encourages students to cross traditional boundaries in their own work and to focus on the idea of world building for their projects. This class often includes guest designers and directors.

54-432 Scenic Design: Modern Classical

Spring: 9 units

This is an advanced scenic design class. Scenic design students demonstrate an understanding of visual storytelling through class discussion and practice in the art of theatrical scenic design. Co-taught by Scenic Design faculty built around two plays or musicals, one contemporary and one classical.

54-435 Scenography for Costume Designers

Fall: 5 units

Costume design majors participate in Scenography for the first mini. Scenography is a core design class between scenic designers, costume designers, media designers, and directors collaborating to create projects on paper. This class allows students to experiment away from the pressure of a realized production. The course encourages students to cross traditional boundaries in their own work and to focus on the idea of world building for their projects. This class often includes guest designers and directors.

54-437 Acting IV

Fall: 5 units

An integration of training and craft approaches related to the rehearsal process featuring a comprehensive approach to text. Students will also examine their propensities and limitations in order to expand their emotional physical vocal and intellectual range.

Prerequisites: 54-301 and 54-302

54-438 Acting IV

Spring: 3 units

An integration of training and craft approaches related to the rehearsal process featuring a comprehensive approach to text. Students will also examine their propensities and limitations in order to expand their emotional physical vocal and intellectual range.

Prerequisites: 54-301 and 54-302

54-439 Stage Management Seminar

Fall: 3 units

This class provides stage managers an opportunity to participate in in-depth discussion about the production process. Specific issues related to CMU productions and troubleshooting problems are a particular focus. The class also presents guest speakers on related topics and will work on longer-term projects as needed.

54-440 Stage Management Seminar

Spring

This class provides stage managers an opportunity to participate in in-depth discussion about the production process. Specific issues related to CMU productions and troubleshooting problems are a particular focus. The class also presents guest speakers on related topics and will work on longer-term projects as needed.

54-441 Costume Design for Dance

Fall: 5 units

A mini exploring the design elements specific to the aesthetic and performance requirements of dance. The course will examine the design of costumes at significant points in the history and evolution of dance, from classical ballet to a wide range of modern genres. Coursework will consist of lectures, visual presentations, viewing of filmed footage of notable dance performances, and research and design projects. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: Second year Graduate Costume Design majors and Junior Costume Design students.

54-442 Costume Design for the Classics

Spring: 5 units

This Spring Mini 3 focuses on a range of playwrights and classic theatre genres from among Moliere, Brecht and Shakespeare. Special attention is paid to process, research, critical thinking, character development, style, nuts and bolts and the honing of each individual designer's skills. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: First year Graduate Costume Design majors and Junior Costume Design students.

54-443 Costume Construction II

Fall: 6 units

FOR: All Costume Majors have priority Advanced problems in costume building and pattern development are individually assigned to strengthen the skills of the student. Projects may be drawn from actual designs for productions if the challenge is suitable for the student's development. This course may be taken for 1 or 2 semesters, starting either Fall or Spring PRE-REQUISITES: Both semesters of Costume Construction I Prerequisites: 54-343 and 54-344

54-444 Draping for the Costume Designer II

Spring: 6 units

tba

54-445 Professional Preparation 1

Fall: 3 units

A brief introduction for design-oriented pre-professionals to the issues, challenges and conventionally-held practices of responsible self-employment. Specific topics such as branding, resumes, cover letters, union contracts, websites and taxes will be introduced through lectures, guests, discussions and handouts. No testing outside of class is anticipated for the successful completion of this course. Prerequisite: open to Seniors only

54-446 Professional Preparation 2

Spring: 3 units

An introduction to the issues and conventionally held practices for the development of responsible self-employment by design-oriented professionals. Discussions investigate the challenges of conducting business within the competitive marketplace of performance-based industries.

54-447 Figure Drawing

Fall and Spring: 3 units

This year-long course explores the realistic and expressive depiction of the human form primarily in two dimensional media. Working primarily from the live model, exercises will be undertaken that address gesture, proportion, movement, anatomy and structure, composition and expressive form. Students will experience a variety of media and formal approaches to the figure, working from nude, draped, and clothed male and female models.

54-448 Figure Drawing

Spring: 3 units

Costume Majors have priority, then Design Majors. This course explores the realistic and expressive depiction of the human form primarily in two dimensional media. Working primarily from the live model, exercises will be undertaken that address gesture, proportion, movement, anatomy and structure, composition and expressive form. Students will experience a variety of media and formal approaches to the figure, working from nude, draped, and clothed male and female models. A primary goal of the class is to develop the ability to create the human figure from imagination, based on intensive empirical study of the forms and structures of the human body from life.

54-449 Dramaturgy Professional Prep 1

Fall: 3 units

Professional Prep for Dramaturgy students

54-450 Painting for the Theatrical Designer

Spring: 9 units

This studio course engages students in watercolor and acrylic study of subjects relative to the development of scene and costume designers. The human figure, architecture, landscape, furniture, clothing, accessories, fabrics, props and building materials for both scenery and costumes are explored. Rigorous practice required. PRE-REQUISITE: Drawing for the Theatrical Designer. All others: Portfolio Review and special permission of teacher required. FOR: All Design/PTM majors- specifically scene and costume design students Prerequisite: 54-473

54-451 Architectural Lighting Design

Fall: 9 units

Missing Course Description - please contact the teaching department.

Prerequisites: 54-349 and 54-350 and 54-352

54-452 Architectural Lighting Design

Spring: 9 units

tbd

Prerequisite: 54-252

54-453 Production Management Workshop I

Fall: 3 units

Investigates the organization, planning and interpersonal skills required to successfully manage a live theatrical production. Course is discussion based on 1) participants experience in laboratory productions in the School of Drama, 2) current practical examples of experiences of professional production managers, and 3) contemporary management texts. Topics covered include: Budgeting, Scheduling, Communication, and Project Management. Permission of instructor required.

54-454 Advanced Topics in Stage Management I

Spring: 3 units

For Production Management and Stage Management majors.

54-455 Production Data Manipulation

Spring: 6 units

Required for Production Management / Stage Management majors.

54-456 Production Management Workshop

Spring: 3 units

Investigates the organization, planning and interpersonal skills required to successfully manage a live theatrical production. Course is discussion based on 1) participants experience in laboratory productions in the School of Drama, 2) current practical examples of experiences of professional production managers, and 3) contemporary management texts. Topics covered include: Budgeting, Scheduling, Communication, and Project Management. Permission of instructor required.

54-457 Directing: Production IV

Fall: 12 units

SENIOR DIRECTING PROJECT: This is a 90-minute, public, fully-designed presentation directed by a 4th-Year Directing student with the following goals: to publicly realize a playwright's purpose for a live audience; to tell an entire theatrical story with a beginning, progression & ending; to work as a team with actors & design team to shape a cohesive & coherent theatrical presentation; to extend practical understanding of Theatre as a collaborative process; to synthesize & apply prior studies at Carnegie Mellon.

54-458 Directing: Production IV

Spring: 10 units

SENIOR DIRECTING PROJECT: This is a 90-minute, public, fully-designed presentation directed by a 4th-Year Directing student with the following goals: to publicly realize a playwright's purpose for a live audience; to tell an entire theatrical story with a beginning, progression & ending; to work as a team with actors & design team to shape a cohesive & coherent theatrical presentation; to extend practical understanding of Theatre as a collaborative process; to synthesize & apply prior studies at Carnegie Mellon.

54-459 Future Stages for Undergrad Directors and Dramaturgs

6 units

FUTURE STAGES is a graduate level course (Drama undergraduates by permission only) which combines options from the School of Drama in a new configuration: through working collaboratively across disciplines, students investigate multimedia approaches to contemporary theater and new ways of storytelling. Directors, designers, actors, and dramaturgs work in groups to generate original ideas, images, texts, and material in a workshop environment. These working groups create projects over the course of the semester which are shown in informal presentations. The emphasis is on process, not product — devising an interdisciplinary performance requires a keen focus on combining creative invention with a rigorous structure of concept development — both of which are explored here. We also examine the work of several significant contemporary theater artists whose work approaches collaboration across a variety of disciplines. Artists have included: Ariane Mnouchkine, Dumbtype, Complicite, Ralph Lemon, Robert LePage, and more. Students learn to define and distinguish these artist's approaches through viewing video excerpts, readings, and discussion. This class is an opportunity to explore avenues outside of traditional production modes and beyond each student's individual discipline. We focus on the process of creating a theatrical language which truly integrates disciplines. Prerequisite: 54-222

54-460 Future Stages for Undergrad Designers

Spring

FUTURE STAGES is a graduate level course (Drama undergraduates by permission only) which combines options from the School of Drama in a new configuration: through working collaboratively across disciplines, students investigate multimedia approaches to contemporary theater and new ways of storytelling. Directors, designers, actors, and dramaturgs work in groups to generate original ideas, images, texts, and material in a workshop environment. These working groups create projects over the course of the semester which are shown in informal presentations. The emphasis is on process, not product — devising an interdisciplinary performance requires a keen focus on combining creative invention with a rigorous structure of concept development — both of which are explored here. We also examine the work of several significant contemporary theater artists whose work approaches collaboration across a variety of disciplines. Artists have included: Ariane Mnouchkine, Dumbtype, Complicite, Ralph Lemon, Robert LePage, and more. Students learn to define and distinguish these artist's approaches through viewing video excerpts, readings, and discussion. This class is an opportunity to explore avenues outside of traditional production modes and beyond each student's individual discipline. We focus on the process of creating a theatrical language which truly integrates disciplines. Prerequisite: 54-231

54-461 Production Preparation IV

Fall

Participation in School of Drama productions, usually in supervisory roles in design or production. Prerequisites: 54361 and 54362
Prerequisites: 54-361 and 54-362

54-462 Production Preparation IV

Spring

Participation in School of Drama productions, usually in supervisory roles in design or production.
Prerequisites: 54-361 and 54-362

54-463 Dramaturgy Research Hours

Fall and Spring

TBD

54-464 PTM Professional Practice

Spring: 3 units

A seminar about issues surrounding a career as a technical manager. In a series of presentations and discussions students will encounter tools and strategies for job seeking and personal promotion. Guest lecturers will present materials on professional obligations like insurance and taxes and non-salary compensation like retirement and health benefits.

54-466 Advanced Media Design II

Spring: 2 units

This is a laboratory experience designed to give practical experience implementing standard stage machinery in a production context. Specific content is dependent on the needs of current productions.
Prerequisites: 54-350 and 54-465

54-467 Costume Design with Music

Spring: 5 units

A rigorous second semester exploration of costume design for musicals and opera that engages students in aesthetic and practical techniques applied toward these two genres. Special attention paid to music skills, process, research, designing for principals and chorus, swatching, nuts and bolts and the honing of each designer's individual skills. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: First year Graduate Costume Design majors and Senior Costume Design students.

54-468 Theater ManagementIntermittent: 6 units
to be determined**54-469 Dance Lighting Design**

Fall: 2 units

This class meets during weeks 8-15 of the fall 2011 semester.

54-470 Costume Rendering

Spring: 9 units

Mediums such as pencil, colored pencil, marker, ink, Doctor Martin's dyes, collage, watercolor and acrylic are explored in this studio setting. Male and female models pose nude and in clothing. Rigorous practice required. PRE-REQUISITE: Drawing for the Theatrical Designer. All others: Portfolio Review and special permission of teacher required. FOR: Advanced Costume Design majors.
Prerequisite: 54-473

54-473 Drawing for Theatrical Designers

Fall: 9 units

This semester-long basic drawing course focuses on developing hand-eye coordination through discreet exercises that allow the theatre student multiple entry points into drawing. Developed for theatrical design students, accurate drawing of proportion while viewing first hand subjects and research images is stressed. Marker and pencil use only. Rigorous practice required. PRE-REQUISITE: Design/PTM major. All others: Portfolio Review and special permission of teacher required. FOR: First semester Graduate Design and Production Students, First semester Junior Costume Majors, other Design/PTM students by consent of instructor.

54-475 Advanced Topics in Stage Management II

Fall: 3 units

Special topics in Stage Management for the experienced manager

54-477 Technical Direction III

Fall: 6 units

Required for all senior undergraduate Technical Direction students. This "capstone" course is the second semester of a sequence requiring application of concepts from earlier courses including Standard Scenery Construction, Production Planning, Structural Design, Stage Machinery Design and Technical Design I. This is a project-based course requiring weekly presentation of solutions to various "unusual" technical challenges, drawn from actual production experiences. Thorough documentation (shop drawings, budgets, build schedules, etc.) is a requirement for each project.
Prerequisite: 54-378

54-478 Television Lighting Design

Fall: 1 unit

This course meets for a few weeks in the fall semester. Contact the instructor for details.

54-479 Television Lighting Design

Intermittent: 2 units

tbd

Prerequisite: 54-252

54-480 Technical Direction IV

Spring: 6 units

This class gives the basics of music theory, musical terminology and score reading. Students focus on the difference in various musical scores, ie. piano/vocal, full, hand written scores. Students are guided in classroom listening which a wide variety of music including, opera, musical theatre, ballet, and choral/orchestra works.
Prerequisite: 54-477

54-487 Dramaturgy: Production II

Fall

Working as a production dramaturg for a season show or a professionally-produced show at a LORT or similarly-ranked theatre in the US or abroad, in senior year.

54-488 Dramaturgy: Production II

Spring

Working as a production dramaturg for a season show or a professionally-produced show at a LORT or similarly-ranked theatre in the US or abroad, in senior year.

54-489 Dramaturgy: Internship

Fall: 9 units

Professional internship with a dramaturg at a LORT or similarly-ranked theatre in the US or abroad.

54-490 Dramaturgy: Internship

Spring: 9 units

Professional internship with a dramaturg at a LORT or similarly-ranked theatre in the US or abroad.

54-491 Concert Lighting Design

Fall: 9 units

description tbd

54-493 Business of Acting

Fall: 4 units

This course introduces the (advanced) actor to various aspects of the professional world. Emphasis is placed on the audition and interview process for casting directors, talent agents and personal managers. Each student will present either an individual or small group project chosen from a wide ranging list of topics which include performers unions, various production contracts, New York and regional theater seasons, professional publications and web sites. Occasional tests are administered on the subject of current Broadway and Off-Broadway seasons. Registration for this course is limited to Drama majors only.

Prerequisites: 54-301 and 54-302

54-494 Business of Acting

Spring: 4 units

The course introduces the (advanced) actor to various aspects of the professional world. Emphasis is placed on the audition and interview process for casting directors, talent agents and personal managers. Each student will present either an individual or small group project chosen from a wide ranging list of topics which include performers unions, various production contracts, New York and regional theater seasons, professional publications and web sites. Occasional tests are administered on the subject of current Broadway and Off-Broadway seasons.

Prerequisites: 54-301 and 54-302

54-498 Expanded Theater Fusion Studio

Intermittent: 10 units

As the boundaries between theater, art, entertainment and everyday life continue to expand through engagement with new technologies, it is critical that emerging artists and technologists be provided with the tools, language, and vision to thrive in the new millennium. Expanded Theater will reanimate classical modes of performance with media, networks, robotics, locative applications, and mobile systems. Considering theater as an ancient technology of mass participation and social cohesion, this fusion studio explores how emerging technologies can expand upon the basic theatrical relationships in new and culturally relevant ways. Collaboration and integration of design, media and storytelling is critical to this approach. Experimentation with new forms can reanimate the basic values of theater; the essential nature of a live event, the possibility of visionary spectacle, and the creation of meaning in dialogue with an audience. Expanded Theater is an opportunity to explore avenues outside of traditional theatrical production modes and beyond each student's individual discipline. The curriculum combines resources from Carnegie Mellon's Schools of Art and Drama, Integrative Design, Arts, and Technology (IDeATe), the Emerging Media Masters (EM2), Computer Science, the Robotics Institute, and their collaborators across the university in a new configuration. Expanded Theater will explore domains ranging from site specific and networked-based performance and interventionist practices, to pervasive social media technologies and their influence on interpersonal communication. The goal is to investigate contemporary languages that allow authors, actors and technologists to collaborate in ways that push beyond our present understanding of theatrical production and reception.

54-499 Advanced Digital Image

Intermittent: 6 units

Advanced Digital Image: (Mini) This class is designed to teach students how to conceive, create and present large scale, professional-quality imagery at "realistic" budget levels. Students choose specific theatrical scenes and create a media based solution for them. Through in-class workshops and Media Lab work-time, this class covers High Definition video production, editing, animation & live video systems for the stage as well as a variety of media-server based presentation technologies. For Juniors, Seniors and Grads. No Prerequisite Open to non-majors

54-500 Voice Lab

Fall and Spring: 5 units

FOR MUSIC THEATRE MAJORS ONLY. Singing Voice based on speech-level and classical singing techniques, required of all Musical Theatre Majors. Lessons are private, for the duration of one hour per week. Voice Lab combines all students of Musical Theatre in a one-hour performance class, where repertoire is performed for faculty and students alike. Training is progressive, with each semester building on the vocal mastery achieved from the previous semester. Repertoire spans from classical to rock, but with an emphasis on songs extracted from the American Musical Canon.

54-505 Ear Training

Fall: 1 unit

Ear Training for sound designers and audio technologists. Introduction and development of skills and techniques for discerning, measuring and expressing the physical qualities of sound with accuracy and sensitivity. Topics include recognizing frequencies (1/3 octave and dual-octave) and analyzing effects and processing (pitch, amplitude, time domain and timbral). This course is open to Drama Sound Design majors/minors, Music Technology major/minors or by permission of the instructor.

54-509 Theatrical Sound System Design

Fall: 9 units

Intensive course exploring the theory, art and technology of large scale sound system design for entertainment, specifically live theater productions.

Prerequisites: Intro to Sound Design for Theatre and Production Audio, OR permission of instructor.

Prerequisites: 54-166 and 54-666

54-511 Millinery I

Fall: 9 units

This course provides the student with a working knowledge of the basic practices of the theatrical milliner. Focus is given to the development of professional level skills in the areas of buckram, and felt constructions. The student is introduced to industry accepted techniques, materials, and equipment.

54-517 Director's Colloquium

Fall: 1 unit

Directors Colloquium is a weekly meeting for undergraduate Directing majors and BXA students in directing. Specific topics in directing are discussed and School of Drama productions are critiqued.

54-518 Director's Colloquium

Spring: 1 unit

Missing Course Description - please contact the teaching department.

54-519 Acting for the Camera

Fall: 6 units

This course presents the skills necessary to work as an actor in the film and television industry. We will put into practice proficiencies and techniques acquired during previous training, adapt those tools, and learn the new skills required when working for the camera.

Prerequisite: 54-302

54-520 Acting for the Camera

Fall and Spring: 6 units

This course presents the skills necessary to work as an actor in the film and television industry. We will put into practice proficiencies and techniques acquired during previous training, adapt those tools, and learn the new skills required when working for the camera.

Prerequisite: 54-302

54-524 Dance Lighting Design

Spring: 3 units

DANCE LIGHT!

Prerequisite: 54-469

54-525 Entertainment Lighting Programming

Fall: 4 units

Students learn and practice programming techniques on the grandMA2 series of lighting control consoles. Advanced programming techniques are explored, including media server control and user-defined commands for the console. Different applications are introduced, but the primary focus is on programming for live music performance.

Prerequisite: 54-349

54-527 Automated Lighting Workshop

Spring

Automated Lighting Workshop consists of four distinct modules. The first focuses on the operation and maintenance of equipment that falls into the category of automated lighting. The second module focuses on the programming of media servers using lighting consoles. The third module concentrates on the development of previsualization skills using LightConverse software. In the fourth portion of the class students design and engineer a realized automated lighting rig. Each portion of the course carries a unit load of 2. Students may register for any combination of these modules for a maximum total of 8 units. Any portion of the course may be repeated in subsequent semesters.

54-534 Costume Crafts: Theatrical Footwear

Spring: 3 units

tba

54-535 Costume Crafts: Fabric Modification

Spring: 3 units

Students will learn fabric modification processes beyond traditional paint and dye. Topics may include devore, felting, extruded silicone, tambour beading, cyanotype, and needle arts. For Costume Design or Production majors only.

54-539 Fabric Dyeing I

Fall: 9 units

tba

54-560 Interactive Technology and Live Performance

Spring: 10 units

This studio course considers the performance skills, design aesthetics, and technical issues unique to effective communication in digital and networked storytelling and performance environments. Through weekly projects, students will develop skills in working with and/or creating a wide range of technologies for stage, film, video, the Internet, and performance art, including: systems for motion capture and CG avatars; voiceover and ADR; remote direction and teleprompting; interactive lighting, projections, and costumes; improvisation with synthetic (AI) agents; and distributed systems for coordinating large-scale participatory events in the public sphere. In so doing, the course explores the ways in which these technologies are changing our understanding of the actor's body and shifting the nature of performance itself.

54-587 Dramaturgy Production III

Fall and Spring

TBA

54-588 Dramaturgy Production III

Spring

For Dramaturgy majors.

54-592 Costume Crafts: Theatrical Armor

Fall: 4 units

This mini course introduces the student to the world of armor creation for the stage. Techniques covered range from traditional to revolutionary and provide the student with a breadth of possibilities geared toward solving the general conundrum of successful armor for the theatrical production. Prerequisite: 54-538

54-599 Woody Allen and Mel Brooks films

Fall: 6 units

TBA

54-666 Production Audio

Spring: 6 units

Introduction to the theories and technologies used in sound system design for theater and live entertainment.

54-721 Graduate Directing: Text to Stage

Fall: 6 units

to be determined

54-722 Graduate Directing: Text to Stage

Spring

Missing Course Description - please contact the teaching department.

54-729 Graduate Automated Lighting Workshop

Fall and Spring

Automated Lighting Workshop consists of four distinct modules. The first focuses on the operation and maintenance of equipment that falls into the category of automated lighting. The second module focuses on the programming of media servers using lighting consoles. The third module concentrates on the development of previsualization skills using LightConverse software. In the fourth portion of the class students design and engineer a realized automated lighting rig. Each portion of the course carries a unit load of 2. Students may register for any combination of these modules for a maximum total of 8 units. Any portion of the course may be repeated in subsequent semesters.

54-755 Drama Practicum

Summer: 3 units

This course provides 3 units of pass/fail credit for students participating in a drama related internship. The student must be registered for this course during the internship, in order to earn the credit. At the end of the term, the student's supervisor must email the academic advisor with a brief statement describing the student's activities, and an evaluation of the student's performance. Students are required to submit a statement, reflecting on insights gained from the internship experience. Upon receipt of both statements, the academic advisor will assign a grade of either P or N, depending on the outcome.

54-756 Graduate Theatre for the Ear

Spring: 6 units

Survey of aural storytelling with technology focusing on forms with no visual component. Topics include the history of radio drama to present day, radio sound art, cut-up and tape manipulation, comedy records and podcast dramas. Prerequisites: 54-767 Graduate Conceptual Sound Design 1 & 54-768 Graduate Conceptual Sound Design 2 OR 54-791 Playwriting I. Restrictions: The course is open to Graduate Sound Design majors, Graduate Dramatic Writers or with permission of the instructor.

54-759 Working with Dramaturgs

Intermittent: 3 units

TBA

54-760 Grad Leadership Workshop: Ethics & Innovation

Intermittent: 6 units

For Production Management and Stage Management majors

54-766 Graduate Introduction to Sound Design for Theatre

Spring: 6 units

Students explore the basic principles and theories of sound design from technical, psychological and aesthetic standpoints. Course work includes instruction in the controllable properties of sound, practical planning of sound plots, cue creation, and the design process. Restrictions: Open to all Graduate Drama Majors, CFA graduate students or with permission of instructor.

54-773 Graduate Couture Sewing Techniques

Intermittent: 6 units

This course introduces the student to advanced sewing techniques used in the creation of both fashion and theatrical clothing.

54-780 Graduate Fabric Painting

Spring: 9 units

Students gain an understanding of the products and techniques involved in a broad range of fabric painting processes as well as pattern development and creation of registered yardage and how these can enhance the theatrical costume product.

Prerequisite: 54-845

54-795 Graduate Costume Crafts: Casting and Moldmaking

Spring: 6 units

This mini course opens the world of mask creation to the adventurous student. A broad range of techniques are touched upon and explored allowing students to pick and choose those processes which appeal to their aesthetic and apply to their needs.

54-815 Graduate Negotiation and Conflict Management

Fall: 3 units

TBD

54-819 Graduate Figure Drawing

Fall and Spring: 3 units

This year-long course explores the realistic and expressive depiction of the human form primarily in two dimensional media. Working primarily from the live model, exercises will be undertaken that address gesture, proportion, movement, anatomy and structure, composition and expressive form. Students will experience a variety of media and formal approaches to the figure, working from nude, draped, and clothed male and female models.

54-822 Graduate Directing: Future Stages II

Spring

Future Stages for second-year Graduate Directors

54-880 Graduate Special Topics in Media: Mediated Reality

Spring

This is an advanced studio course investigating mediated reality technologies and location based interactivity and their potential uses for live performance. The course is technically and conceptually demanding. We will work primarily in Autodesk Maya and Unity 3d, as well as work with various networking technologies for experiencing merged digital and real worlds. The course will start with rapid skills training, then students will work in small groups on developing content rich applications for these technologies. Through readings and discussion of a variety of contemporary works students will come up with testable ideas that will be prototyped in the second half of the semester.

54-884 Graduate Future Stages

Fall: 6 units

FUTURE STAGES combines options from the School of Drama in a new configuration: through working collaboratively across disciplines, students investigate multimedia approaches to contemporary theater and new ways of storytelling. Directors, designers, actors, and dramaturgs work in groups to generate original ideas, images, texts, and material in a workshop environment. These working groups create projects over the course of the semester which are shown in informal presentations. The emphasis is on process, not product — devising an interdisciplinary performance requires a keen focus on combining creative invention with a rigorous structure of concept development — both of which are explored here. We also examine the work of several significant contemporary theater artists whose work approaches collaboration across a variety of disciplines. Artists have included: Ariane Mnouchkine, Dumbtype, Complicite, Ralph Lemon, Robert LePage, and more. Students learn to define and distinguish these artist's approaches through viewing video excerpts, readings, and discussion. This class is an opportunity to explore avenues outside of traditional production modes and beyond each student's individual discipline. We focus on the process of creating a theatrical language which truly integrates disciplines.

54-898 Graduate Composition for Theatrical Sound Design 2

Spring: 6 units

This course will concentrate on further developing compositional skills for use in theatrical sound design. The full length of this course is designed to take place over two semesters. This is the second semester and builds on compositional techniques such as writing melody, harmony, counterpoint and orchestration techniques. The second semester focuses particularly on more advanced skills in composition within a theatrical context. Through projects distributed throughout the semester students practice the skill-based techniques of music notation, orchestration, synthesis, sequencing, working with instrumentalists and the creation and utilization of sample-based instruments. This course will also cover textual analysis as it applies to both the inspiration for composition and to the more direct challenge of setting music to text.

54-905 Graduate Ear Training

Spring: 1 unit

Ear Training for sound designers and audio technologists. Introduction and development of skills and techniques for discerning, measuring and expressing the physical qualities of sound with accuracy and sensitivity. Topics include recognizing frequencies (1/3 octave and dual-octave) and analyzing effects and processing (pitch, amplitude, time domain and timbral). This course is open to Drama Sound Design majors/minors, Music Technology major/minors or by permission of the instructor.

54-939 Graduate Entertainment Lighting Programming

Fall: 4 units

Students learn and practice programming techniques on the grandMA2 series of lighting control consoles. Advanced programming techniques are explored, including media server control and user-defined commands for the console. Different applications are introduced, but the primary focus is on programming for live music performance.
Prerequisite: 54-771

54-964 Graduate Scenic Design: Moving the Musical

Fall: 5 units

This course will explore methods of designing a musical, emphasizing the ways in which the movement of the scenic units informs the design and helps the audience understand the story being told.

54-972 Graduate PTM Professional Practice

Fall: 3 units

A seminar about issues surrounding a career as a technical manager. In a series of presentations and discussions students will encounter tools and strategies for job seeking and personal promotion. Guest lecturers will present materials on professional obligations like insurance and taxes and non-salary compensation like retirement and health benefits.

54-973 Costume Production Thesis

Fall and Spring: 12 units

TBD

54-997 Graduate Sound Design For Interactive Environments & Non-Linear Storytelling

Spring: 9 units

This course will examine the process, execution and implementation of sound design for interactive and non-linear storytelling paradigms. Emerging trends in immersive theater, gaming, installation art and multimedia place unique demands on the sound designer both in terms of content and delivery. The student will explore how these demands effect the fundamental processes of design, development of content and flexible delivery systems. Through a combination of directed readings, exploration of current & emerging trends, and project assignments the student will be encouraged to experiment and explore design modes and methodologies that support this flexible method of storytelling.
Prerequisites: 54-867 or 54-868

54-998 Graduate Film Sound Design

Intermittent: 9 units

A one semester course introducing the art of film sound design. Topics include the history of sound design for film, critical theories about cinematic sound design and an introduction to the techniques used especially as they relate to and differ from theatrical sound design. Prerequisites: 54-767 Graduate Conceptual Sound Design 1. Restrictions: The course is open to Graduate Drama majors or by permission of the instructor.
Prerequisites: 54-867 and 54-868

Economics Courses

73-050 Study Abroad

Intermittent

This course number is a place holder and assigned to economics students studying abroad by CMU's Office of International Education.

73-051 Study Abroad

Intermittent

This course number is a place holder and assigned to economics students studying abroad by CMU's Office of International Education.

73-100 Principles of Economics

Fall and Spring: 9 units

Literally, an introduction to economic principles, the goal of this course is to give students an understanding as to what constitutes good "economic thinking". This thought process is grounded in the construction and use of economics models. Drawing on issues in both microeconomics and macroeconomics, fundamental principles are shown to transcend particular examples and allow the field to be seen as a coherent, unified whole. (Lecture, 2 hours; Recitation, 1 hour).

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73100/principles-of-economics>

73-101 Freshman Seminar

Fall and Spring: 9 units

A topics-based course for first-year students. This course is not a supplement nor a replacement for Principles of Economics. Instead, it meant to introduce students to how social scientists (particularly economists) examine governments, societies, markets, and organizations. Subjects discussed vary from year-to-year and from instructor-to-instructor; recent subjects include behavioral economics, environmental policy, defining progress, and more. (Seminar, 3 hours)

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73101/freshman-seminar-in-economics>

73-111 Internship I

All Semesters

By permission of the Undergraduate Economics Program.

73-112 Internship II

All Semesters: 3 units

By permission of the Undergraduate Economics Program.

73-113 Internship III

All Semesters: 3 units

By permission of the Undergraduate Economics Program.

73-148 Environmental Economics

Intermittent: 9 units

A course for non-majors which explores the interplay between economics and environmental issues. Topics include: market failures and environmental problems, economically efficient allocations of environmental resources, and the intended and unintended consequences of public policies designed to improve the environment. Practical issues surrounding the feasibility of implementing theoretically efficient principles and policies are analyzed, and alternative policies that might achieve better results in practice are investigated. (Lecture, 3 hours).

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73148/environmental-economics>

73-155 Legonomics: Building Blocks of Economic Analysis

Spring: 9 units

The overall theme of the course is how to use data and measurement to form models for economic analysis, with the emphasis not on any kind of formal statistical or econometric analysis, but rather on how to do the inductive science of translating perceived patterns in data into a usable model in the sense of ignoring noise and abstracting from patterns to hypothesize relationships. We will work with historical data sets to "discover" Malthusian economics and model economic relationships that governed the human condition up until the mid-1700's. We will then move on to the industrial revolution and "discover" the role of technology, culminating in an overview of modern thinking about economic growth. Questions we will consider as well as looking at looking at the current public policy responses to them are: Why are some countries rich and some are poor? Why have some countries experienced rapid economic development; what can be done to foster development of others that continue to languish? Does education lead to increased household wealth and national wealth? How are new technologies affecting economic development and economic opportunities? Can we improve design of electronic markets to take advantage of the vast opportunities for trade and exchange afforded by the internet? (Lecture, 3 hours)

Prerequisites: 21-111 and 73-100

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73155/legonomics-building-blocks-of-economic->

73-230 Intermediate Microeconomics

Fall and Spring: 9 units

This course is a calculus-based study of microeconomics. Topics in partial equilibrium analysis include supply and demand, consumer theory, theory of the firm, profit maximizing behavior, monopoly theory, and perfect competition. The course concludes with an introduction to general equilibrium analysis and the welfare laws. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-120 or 21-112) and (21-268 or 21-269 or 21-259 or 21-256) and 73-100

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73230/intermediate-microeconomics>

73-240 Intermediate Macroeconomics

Fall and Spring: 9 units

Through macroeconomic models built upon microeconomic foundations, insights are developed into economic growth processes and business cycles. Topics include aggregation and measurement, national income, business cycle measurement, economic welfare theorems and social inefficiencies, the effect of government fiscal policy upon employment and productivity, and the relationship between investment, interest rates and economic growth. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 73-100 and 73-230 and (21-120 or 21-112) and (21-268 or 21-259 or 21-256 or 21-269)

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73240/intermediate-macroeconomics>

73-270 Writing for Economists

Fall and Spring: 9 units

A writing course specifically designed for third-year Economics majors and additional majors. Students gain experience with technical writing techniques and skills needed for both their senior thesis and their eventual professional careers. The course emphasizes both individual and group projects. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 76-101 and 73-100 and 73-230 and 73-240

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73270/writing-for-economists>

73-274 Econometrics I

Spring: 9 units

This course will provide an introduction to the analysis of economic field data. The first part of the course will discuss how data is generated and how this affects the inferences we can make. In particular, we will look at the difficulties of working with field data and learn how non-random sampling leads to poor inferences. We will then move on to some simple statistical techniques, in particular OLS and its extensions as well as Maximum Likelihood Estimators. We will also learn about the large sample properties of these estimators. At the end of the course, students should be able to understand what inferences can be made with field data and some basic statistical techniques that can be used to uncover patterns in the data. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade standard of "C" applies only to economics courses. Note: Offered for the first time in the Spring 2015 semester.

Prerequisites: (21-256 or 21-259) and 73-100 and 73-230 and (36-217 or 36-225)

Course Website: http://tepper.cmu.edu/prospective-students/course-page/73274/econometrics_i

73-310 Evolution of Economic Ideas and Analysis

Fall: 9 units

This course will be organized around the study of several central topics in the development of economics such as: the "invisible hand;" classical analysis of trade, value, and income distribution; the marginalist revolution; general equilibrium theory; classical monetary economics; Keynesian macroeconomics; and recent trends in theory and empirical analysis. Where possible, examination of the contemporary policy issues motivating major analytical developments will be included. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-120 or 21-112) and (21-256 or 21-259 or 21-269 or 21-268) and 73-100 and 73-230 and 73-240

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73310/evolution-of-economic-issues-and-analy>

73-315 Market Design

Spring: 9 units

The market design class is going to cover three main subjects: matching, auctions, and, time allowing, marketplaces. Matching topics may include: Two-Sided Matching and Medical Residents House Allocation and Kidney Exchange School Choice Law Clerks and College Early Admission Auction/ Marketplace topics may include: Designing Optimal Auctions Common Value Auctions Multi-Unit Auctions and Treasury Auctions Multi-Item Auctions and The Assignment Model Sponsored Search Auctions The FCC and Simultaneous Ascending Auctions Package Auctions and Radio Spectrum Introduction to the Economics of Platforms Internet Platforms: e-Commerce Internet Markets: Advertising (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-269 or 21-259 or 21-268 or 21-256) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73315/market-design>

73-328 Health Economics

Fall: 12 units

This course will teach the student to use economic analysis to understand critical issues in health care and health policy. We will address issues such as the following: 1. What factors best explain the level and rate of growth of U.S. health expenditures? 2. Does the recent high rate of growth of U.S. health care expenditures make U.S. firms less competitive in international markets? 3. What are some of the likely consequences (intended and unintended) of the proposed reforms to Medicare? 4. Can physicians induce demand for their services? 5. What are the impacts of managed care on the health care system? 6. Do strong affiliations between physicians and health plans hurt competition? (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-268 or 21-269 or 21-259 or 21-256) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73328/health-economics>

73-331 Political Economy of Inequality and Redistribution

Intermittent: 9 units

Three basic types of institution - markets, communities, and states (i.e. public governments) - determine the distribution of economic resources and opportunities in societies. The balance between these governing institutions has changed dramatically over time, at very different rates across societies. This course will begin with economic and political theory on why these differences over time and across countries may exist. Then it will survey some of these differences across both industrialized and pre-industrial societies and investigate their causes and consequences. Some of the questions the course will ask include the following: In the industrialized world, the public sector (government) plays a much larger role in Europe than in the United States. Why is this so? How does this affect the quality of everyday life for different classes of people? How have globalization and technological change affected the distribution of income and social policy in industrialized countries, and how does this affect the public sector? In some tribal societies, people have no access to markets at all. How does this affect distributive behavior within communities? Finally, what might be the ultimate causes of income inequality on a global scale? Are there prehistoric and environmental roots in the ways peoples of different societies live today? This course will examine these questions by studying theoretical and empirical research conducted by economists, economic anthropologists, political economists, and economic geographers on these questions. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 21-120 and (21-256 or 21-268 or 21-269 or 21-259) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/undergraduate/economics/curriculum/course-list>**73-338 Financial Crises and Risk**

Spring: 9 units

This course provides an in-depth examination of the causes of financial crises as well as what governments can do to prevent them or at least reduce their cost. The course is designed to provide an understanding of individual attitudes towards risk and individual decision making about savings and investment under uncertainty, and to use this understanding to evaluate the various economic roles played by financial institutions in helping individuals manage risk, especially those roles which may lead to economic instability and crises. In addition, the course may cover bubbles and swindles, especially when these spillover to the broader macroeconomy; the role of information in banking in normal times and in bank runs; crisis resolution techniques; and the extensive history of attempts to improve regulation so as to reduce the frequency and cost of crises. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230 and 73-240

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73338/financial-crises-and-risk>**73-341 Within the Firm: Managing through Incentive**

Spring: 9 units

We are living in an exciting age of information and knowledge when inspiring employees with a firm becomes increasingly more important. Aligning the objectives of workers, managers, and owners by providing them with appropriate incentives becomes an emerging paradigm in the modern business world. In this course we learn how to reason about incentives both between managers and employees, managers and owners, and within a team of co-workers. We cover a broad range of topics including principal-agent problem, moral hazard, asymmetry of information, incentive in teams, collective decision making, and repeated interactions. These theoretical underpinnings will be illustrated with actual business experience and case studies. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 73-100 and 73-230 and (21-112 or 21-120) and (21-256 or 21-269 or 21-259 or 21-268)

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73341/within-the-firm-managing-through-incent>**73-347 Game Theory for Economists**

Fall: 9 units

An introduction to the theory of non-cooperative games with an emphasis on economic applications. After an initial examination of two-person, zero-sum games, the notion of a Nash equilibrium in an n-person, non-cooperative game is considered. Existence of and refinements to the equilibrium concept are discussed in the context of both normal and extensive form games. Economic applications may include various topics, including Cournot and Bertrand oligopoly models, general competitive exchange equilibrium, and free rider problems. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-256 or 21-259 or 21-269 or 21-268) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73347/game-theory-for-economists>**73-348 Behavioral Economics**

Spring: 9 units

This course introduces students to behavioral economics which is a subfield of economics that incorporates insights from other social sciences, such as psychology, into economic models and aims to explain the anomalies challenging some of the classical economic models. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 21-120 and (21-256 or 21-259 or 21-269 or 21-268) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73348/behavioral-economics>**73-352 Public Economics**

Fall: 9 units

In this course, students analyze the role of governments in market economies and their impact on the behavior and welfare of citizens. Reasons for government intervention in markets are examined in light of some of the economic challenges faced by modern societies in an increasingly globalized marketplace. Topics include: taxation and expenditure policies, externalities and market failure, social security, public assistance and income redistribution programs. There will also be some coverage of the role of local governments in the economy with respect to such issues as crime, urban development and education. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-120 or 21-112) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73352/public-economics>**73-353 Economic Foundations of Regulation with Applications to Financial Markets**

Spring: 9 units

The financial crisis has focused attention on the role of regulation for our financial system and the broader economy. The course will address the foundations of regulation (why regulate?) from various perspectives within the context of a market economy, highlighting the sources of market failure? (such as externalities, adverse selection, and natural monopoly) and potential remedies (such as taxes and fees, disclosure, price regulation, guarantees). The conflicting goals among regulators (and why we have multiple regulators) and their impact on the meaning of regulation will be considered along with regulatory competition/arbitrage. Portions of the course will tackle relatively broad questions such as: Why regulate? What is the law of unintended consequences? What is the objective of a policy advocate? Are regulators and regulatory policies a systemic risk? Are our markets rigged? How can regulators enhance the predictability and credibility of their policies? How costly were government guarantees during the financial crisis? Should we bar insider trading? Should regulations be determined and motivated based upon cost-benefit analysis? How can we evaluate the success or failure of particular regulations and whether they have achieved their objectives? How does the Dodd-Frank Act promote financial stability? What basic aspects of the financial crisis did Dodd-Frank not address? (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-120 or 21-112) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73353/economic-foundations-of-regulation-with>

73-358 Economics of the Environment and Natural Resources

Intermittent: 9 units

An advanced course on the allocation of environmental and natural resources. Topics include: externalities and the misallocation of resources, examining the efficiency/inefficiency of markets for non-renewable resources, intended and unintended consequences of regulatory and tax policies, and modern alternative to regulation such as the creation of new markets and property rights for environmental resources. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses. Prerequisites: 21-120 and (21-256 or 21-259) and 73-100 and 73-230

73-359 Benefit-Cost Analysis

Fall: 9 units

The evaluation of public private sector projects. The theory of benefit-cost analysis and related techniques, such as cost-effectiveness analysis. Attention is given to such issues as valuing goods and services that are not normally traded in the marketplace (e.g., the value of an individual's life) and the social rate of discount. Applications are considered in detail. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-120 or 21-112) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73359/benefit-cost-analysis>

73-363 Econometrics

Fall: 9 units

This course takes as its starting point ordinary-least-squares estimation and the linear regression model, which are presented utilizing vector and matrix notation. This is followed by the application of OLS to non-linear models. Cases are then considered where the various assumptions of OLS do not hold and what corrective actions should be taken. Topics include: nonlinear-least-squares, two-stage estimation, instrumental variables, simultaneous equations, maximum likelihood estimation, and logit/probit models. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade standard of "C" applies only to economics courses. Note: This course will be retired after the Fall 2015 semester. Beginning in Spring 2016 semester, a new econometrics sequence will be offered.

Prerequisites: (21-120 or 21-112) and (21-268 or 21-259 or 21-256 or 21-269) and 73-100 and 73-230 and 73-240 and (36-217 or 21-325 or 36-225) and 36-226

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73363/econometrics>

73-365 Firms, Market Structures, and Strategy

Fall: 9 units

This course is concerned with the economic analysis of industrial markets that are not perfectly competitive. The effects of imperfect competition on firms' decisions (pricing, location, advertising, research and development, among others) are reviewed. Implications of these effects in terms of public policy are also discussed from a variety of perspectives. Finally, applications to actual markets are considered. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-269 or 21-259 or 21-256 or 21-268) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73365/firms-market-structures-and-strategy>

73-372 International Money and Finance

Intermittent: 9 units

The course introduces students to a micro-founded model of the global monetary system. The model is employed to assess the roles of money, banking, and central banking in the management of inflation, employment, and financial stability. Interest rates, the international exchange rate, the trade balance, and international capital flows are explored in terms of the model. The model is used to address controversial issues in international trade and financial relations, as well as current macroeconomic stabilization problems in China, the Euro area, the United States, and elsewhere.

Theoretical points are illustrated with references to historical central bank practices from around the world in recent decades. The course concludes with student briefings on current central bank policies from around the world. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230 and 73-240

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73372/international-money-and-finance>

73-374 Econometrics II

Fall: 9 units

The material covered in this course extends from the material covered in Econometrics I (73-274). The course will include both the theory behind the methods and a hands-on analysis of actual data, providing students the tools for both research and industry jobs. Theories and methodologies covered will include: nonlinear regression models, qualitative response regression models, panel data estimators, simultaneous-equation models, and time series. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade standard of "C" applies only to economics courses. Note: Offered for the first time in the Fall 2016 semester.

Prerequisites: 21-120 and (21-256 or 21-259) and 73-100 and 73-230 and (73-274 or 36-226) and (36-217 or 36-225)

Course Website: http://tepper.cmu.edu/prospective-students/course-page/73374/econometrics_ii

73-375 History of Money and Monetary Policy

Spring: 9 units

This course will consider the evolution of monetary institutions and policies from 550 BC to the present, providing an understanding of the role of monetary policy through a critical evaluation of the mistakes and successes of the past. Specific topics will include: Greek, Roman, and Medieval coinage; metallic systems including strengths and weaknesses of the gold standard and bimetallism; American colonial experiences; French episodes including the 'system' of John Law and the Assignats of the French Revolution; critical British episodes including the Great Debasement and the Restriction of 1797-1821; and the following topics in United States history: the Constitution, early problems, Greenbacks of the Civil War, legal tender cases, the "Crime of 1873," founding of the Federal Reserve, Great Depression, Bretton Woods, the Great Inflation, the Volcker disinflation, and the financial crisis of 2008-10. The course will include a bit of general history and history of economic thought, with just enough economic theory to provide analytical coherence. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 76-101 and 73-100

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73375/history-of-money-and-monetary-policy>

73-394 Development Economics

Intermittent: 9 units

This course will explore issues relating to economic development in low and middle-income countries. We will discuss topics such as economic growth and inequality, education, health, the family, and the markets for land, labor, and credit. We will study how market failures can potentially prevent economic growth in the developing world. Also we explore the effectiveness of different types of policies in promoting development. The course will use both economic theory and empirical methods to answer these questions. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 21-120 and (21-269 or 21-268 or 21-259 or 21-256) and 73-100 and 73-230

73-395 Independent Study in Economics

Fall and Spring

The Independent Study course in economics allows the student to pursue his or her own research interests in any of a variety of topics in economics. A typical independent study course involves a semester long project under the supervision of an appropriate faculty advisor. The nature and scope of the project are determined by the student and faculty advisor. Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 21-120 and (21-268 or 21-256 or 21-259 or 21-269) and 73-100 and 73-230

73-407 Fundamentals of Statistical Modeling

Spring: 9 units

This course provides a one-semester introduction to the theory of probability and mathematical statistics. The course will emphasize probability models and distribution theory; the practice of statistical inference based on the use of maximum likelihood estimation; and applications of statistical modeling and inference, using case studies drawn from the social, physical and biomedical sciences. The use of a computer software package will be an integral part of this course. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 21-120 and (21-269 or 21-259 or 21-268 or 21-256) and (36-247 or 36-220 or 36-208 or 36-202 or 36-309 or 70-208)

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73407/fundamentals-of-statistical-modeling>

73-408 Law and Economics

Spring: 9 units

This course will provide a broad overview of the scholarly field known as "law and economics." The focus will be on how legal rules and institutions can correct market failures. We will discuss the economic function of contracts and, when contracts fail or are not feasible, the role of legal remedies to resolve disputes. We will also discuss at some length the choice between encouraging private parties to initiate legal actions to correct externalities and governmental actors, such as regulatory authorities. Extensive attention will be given to the economics of litigation, and to how private incentives to bring lawsuits differ from the social value of litigation. The economic motive to commit crimes, and the optimal governmental response to crime, will be studied in depth. Specific topics within the preceding broad themes include: the Coase Theorem; the tradeoff between the certainty and severity of punishment; the choice between ex ante and ex post sanctions; negligence versus strict liability; property rules; remedies for breach of contract; and the American rule versus the English rule for allocating litigation costs. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 21-120 and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73408/law-and-economics>

73-421 Emerging Markets

Fall: 9 units

The aim of the course is to understand the economic, political and institutional forces that spur or hinder business activity and success in emerging economies. The course is designed to provide an overview of fiscal, monetary, trade and labor market policies adopted in emerging economies and how these policies have impacted and continue to impact small and large businesses, investment opportunities and the growth potential of these countries. The course will focus on successful emerging economies such as India, China, Chile, Brazil, with broader lessons and comparisons drawn from developed countries, as well as from failures in other developing nations. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230 and 73-240

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73421/emerging-markets>

73-422 Real Estate Economics and Finance

Intermittent: 9 units

The principle objective of this course is to analyze the financial characteristics of real assets and their derivative products, as well as to provide an introduction to their associated institutions. Topics include: residential real estate markets, urban land markets, analysis of mortgages and mortgage markets, commercial property markets, financial valuation of real assets, influence of debt financing on risk and returns, innovations in real estate capital markets, and analysis of asset allocation decisions. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: 21-120 and (21-259 or 21-256) and 73-100 and 73-230

73-433 Environmental Policy and Economics

Fall: 9 units

The primary objective of this course is to encourage students to apply the tools of microeconomic analysis (and to a lesser degree, macroeconomics) to the problems of environmental protection, natural resource management, and energy production and use. The course will begin by introducing students to how an economist approaches problems of market failure commonly found in environmental contexts. Next, we will explore models that characterize solutions to such environmental issues. We will then address questions regarding measurement, the design of environmental regulations, and, finally, we will apply the tools that we have developed during the semester to the problems of climate change, and the optimal management of forests, water resources, and land use. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-256 or 21-259 or 21-269 or 21-268) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73433/environmental-policy-and-economics>

73-449 Social, Economic and Information Networks

Fall: 9 units

Interaction is a fundamental part of social science: firms market products to consumers, people share opinions and information with their friends, workers collaborate on projects, agents form alliances and coalitions. In this course, we will use the emerging field of social networks to put structure on this diverse mass of connections. Using a mixture of theoretical, empirical, and computational methods, we will learn about the structure and function of social networks. We will look at how an individual's position in a social network reflects her role in the community. We will learn to identify tastemakers and trendsetters by looking at how information moves through our increasingly connected society. We will consider how our own position in the social network affects our behavior, opinions, and outcomes. And we will explore where social networks come from, and what affects their structure. The material in this course will be interdisciplinary, drawn from the fields of math, computer science, physics, sociology, political science, and economics. By the end of the course, you will have the tools and knowledge needed to analyze social networks on your own. The course is capped with a project where you will use your skills to answer your own questions. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (36-201 or 70-207) and 73-100 and 73-230 and (21-112 or 21-120) and (21-256 or 21-259 or 21-268 or 21-269)

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73449/social-economics-and-information-network>

73-450 Economics Colloquium

Fall: 1 unit

Economics majors meet for one hour each week to hear discussions on current research by faculty or students, presentations on economics from economists outside academia, and expository talks on selected economics topics not part of the usual curricula. Also will include topics of special interest to undergraduates such as preparation for graduate school and topics in the press. (Colloquium, 1 hour)

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73450/economics-colloquium>

73-465 Technology Strategy

Intermittent: 9 units

This course is about business strategy for technology-intensive industries. Examples of such industries are computer hardware and software, media and entertainment, telecommunications and e-commerce. We will explore the unique economic circumstances facing firms in these industries and identify strategies that enable firms to succeed given these circumstances. You will learn to analyze pricing strategies including versioning and bundling; product standardization decisions; managing product complements; exploiting network effects; managing platform competition. This course will help you understand the unique economic characteristics seen in today's technology-intensive markets and how they impact the strategic interactions among firms and consumers. We will study, for example: Why firms in the IT industry give away their best products for free. Why makers of video gaming consoles subsidize end users (but tax game developers) while computer operating system makers subsidize software developers (but overcharge end users). Why Sony won the Blu-Ray format war against HD-DVD which was sponsored by a whole array of companies. In order to understand how firms strategically interact with consumers in technology-intensive industries this course will use a combination of simple but rigorous analytical models, emerging theories, and formal case studies. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.

Prerequisites: (21-112 or 21-120) and (21-256 or 21-259) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73465/technology-strategy>

73-469 Global Electronic Markets: Economics and the Internet

Fall: 9 units

The information revolution brought about by the Internet is having a dramatic impact on the organization of economic activity. Long-term contractual relationships that once governed corporate procurement are being dismantled as manufacturers use the Internet to market directly to the public. New transportation networks that used to simply move goods from point A to point B are evolving into dynamic inventory pipelines that allow manufacturers to track and even reroute shipments in real time. At the same time, individuals are making use of sophisticated search engines to comparison shop at a scale that would have been physically exhausting even five years ago. In the Economics of E-commerce, we will use the basic tools of economic analysis to understand how and why the changes in information technology are reshaping the economic landscape. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses. Prerequisites: (21-112 or 21-120) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73469/global-electronic-markets>

73-474 The Economics of Ideas: Growth, Innovation and Intellectual Property

Intermittent: 9 units

Healthy economies in many way resemble healthy people they are alive and vibrant, growing and adjusting in response to changing circumstances and what fuels economic growth and innovation are ideas. This course explores the role of ideas in the modern economy. Topics include: models of economic growth, economic efficiency and development, innovation and human capital, intellectual property and public policy issues. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses. Prerequisites: (21-112 or 21-120) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73474/the-economics-of-ideas>

73-476 American Economic History

Intermittent: 9 units

The study of economic history provides important perspective on current economic institutions and policies. A failure to understand the historical evolution of economic institutions or the variety of past economic experience is perhaps the worst shortcoming of many economists. The study of economic history provides an opportunity to test currently fashionable theories against data different from those used in their construction. In fact, this is a course in applied economics. The theories developed in the intermediate courses will be applied to episodes from the past in ways that increase understanding both of the specific historical episodes considered and the economic theories employed. (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses. Prerequisites: 21-120 and (21-256 or 21-259) and 73-100 and 73-230 and 73-240 and (36-202 or 36-208 or 36-220 or 70-208)

73-495 Advanced Independent Study in Economics

All Semesters

The Independent Study course in economics allows the student to pursue his or her own research interests in any of a variety of topics in economics. A typical independent study course involves a semester long project under the supervision of an appropriate faculty advisor. The nature and scope of the project are determined by the student and faculty advisor. Minimum grade standard of "C" applies only to economics courses. Prerequisites: 21-120 and (21-259 or 21-256) and 21-122 and 73-100 and 73-230 and 73-240 and 73-252

73-497 Senior Project

Fall: 9 units

A fourth-year project course, open only to Economics primary and additional majors with Senior standing. Minimum grade standard of "C" applies only to economics courses. Prerequisites: (21-120 or 21-112) and (21-256 or 21-259 or 21-268 or 21-269) and 73-100 and 73-230 and 73-240 and (73-407 or 73-363 or 73-274 or 36-226 or 36-303)

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73497/senior-project>

73-500 Tepper College Honors Thesis I

Fall and Spring

Economics majors with outstanding academic records and intellectual promise will be given the opportunity to undertake original research under the direction of individual faculty members. Research topics are selected by students and approved by faculty. Prerequisites: Senior standing in the Economics Program and permission of the Economics faculty.

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73500/tepper-senior-honors-thesis-i>

73-501 Tepper College Honors Thesis II

Fall and Spring

Economics majors with outstanding academic records and intellectual promise will be given the opportunity to undertake original research under the direction of individual faculty members. Research topics are selected by students and approved by faculty. Prerequisites: Senior standing in the Economics Program and permission of the Economics faculty.

Course Website: <http://tepper.cmu.edu/prospective-students/course-page/73501/tepper-senior-honors-thesis-ii>

Electrical Computer Engineering Courses

18-090 Digital Media Interactions: Signal Processing for the Arts

Fall: 10 units

[IDeATe portal course] - This course presents an overview on manipulating and synthesizing sound, video, and control signals. Signals are the raw materials used in many forms of electronic art and design - electronic music, interactive art, video art, kinetic sculpture, and more. In these fields, signals are used to represent information about sound, images, sensors, and movement. By transforming and manipulating these types of signals, we are able to create powerful new tools for digital art, multimedia applications, music, responsive environments, video and sound installation, smart products, and beyond. In this course we will study Signal Processing from a practical point-of-view, developing tools that can be easily integrated into art-making using the graphical programming environment Max (a.k.a. Max/MSP/Jitter). We will present a survey of Signal Processing techniques used in the sonic and visual arts, and will discuss the mathematical theories underlying these techniques. Students will be encouraged to combine, modify, and extend working examples of software to create original digital artworks. Please note that there will be usage/materials fees associated with this course.

18-099 Special Topics: Mobile App Design & Development

Fall: 12 units

[IDeATe collaborative course] IDeATe is partnering with YinzCam to develop and offer a studio course on mobile app design and development. The course will leverage the extensive expertise of YinzCam on mobile-app development in the sports and entertainment space, both for real-time and asynchronous enrichment of the fan experience and the stadium experience. However, the lessons learned will apply to mobile-app development broadly. Issues covered will include cross-platform development, mobile video, streaming media, real-time content delivery, along with best practices in server-side cloud management for large-scale mobile-app deployment. Please note that this course is for students to take as one of their IDeATe concentration/minor options and will NOT fulfill a CIT/ECE requirement. Open to juniors and seniors. DC and MCS students should take the course after completing another IDeATe collaborative course. Prerequisites: 18-090 or 15-104 or 62-150

18-100 Introduction to Electrical and Computer Engineering

Fall and Spring: 12 units

The goals of this freshman engineering course are: * To introduce basic concepts in electrical and computer engineering in an integrated manner; * To motivate basic concepts in the context of real applications; * To illustrate a logical way of thinking about problems and their solutions, and; * To convey the excitement of the profession. These goals are attained through analysis, construction and testing of an electromechanical system (e.g., a robot) that incorporates concepts from a broad range of areas within Electrical and Computer Engineering. Some of the specific topics that will be covered include system decomposition, ideal and real sources, Kirchhoff's Current and Voltage Laws, Ohm's Law, piecewise linear modeling of nonlinear circuit elements, Ideal Op-Amp characteristics, combinational logic circuits, Karnaugh Maps, Flip-Flops, sequential logic circuits, and finite state machines. 3 hrs. lec., 1 hr. rec., 3 hr. lab. Corequisite: 21-120

18-200 Emerging Trends in Electrical and Computer Engineering

Fall: 1 unit

This class consists of a series of individual lectures given by different faculty members and distinguished alumni. The lectures are designed to serve the following purposes: 1) provide students a good understanding of our curriculum structure and the courses in each of our five principle subject areas; 2) introduce to students the emerging trends in electrical and computer engineering and the relevance of our courses; 3) present to students our faculty's research fields; 4) discuss basic learning and working ethics; 5) prepare students career-making skills; 6) introduce new undergraduate courses and research opportunities. The class will contain 12 lectures from faculty members, 2 lectures on learning and working ethics, and 2 lectures from our alumni. Students are required to attend each lecture. An award for the best lecturer, selected by students, will be given at the end of the semester. 1 credit, 1 hr per week, pass/fail, required to graduate. Sophomore standing required.

Prerequisite: 18-100

18-202 Mathematical Foundations of Electrical Engineering

Fall and Spring: 12 units

This course covers topics from engineering mathematics that serve as foundations for descriptions of electrical engineering devices and systems. It is the corequisite mathematics course for 18-220, Fundamentals of Electrical Engineering. The topics include: (1) MATLAB as a robust computational tool, used to reinforce, enrich and integrate ideas throughout the course, including software exercises and projects in combination with homework assignments, (2) Complex Analysis, including rectangular and polar representations in the complex plane with associated forms of complex arithmetic, powers, roots and complex logarithms, complex differentiation, analytic functions and Cauchy-Riemann equations, complex Taylor series, complex exponential, sinusoidal and hyperbolic functions, and Euler's formula, (3) Fourier Analysis, including orthogonality of sinusoids, trigonometric and exponential forms of Fourier series, Fourier integrals and Fourier transforms, (4) Linear, Constant-Coefficient Differential Equations, including complex exponential solutions to homogeneous equations and particular solutions with polynomial and sinusoidal driving functions described by phasors, (5) Difference Equations, with emphasis upon their relationship to differential equations, and (6) Linear Algebra and Matrices, including matrix arithmetic, linear systems of equations and Gaussian elimination, vector spaces and rank of matrices, matrix inverses and determinants, eigenvalue problems and their relationship to systems of homogeneous differential equations. 4 hrs. lec., 1hr. rec.

Prerequisites: 21-122 or 21-118 or 21-123

18-213 Introduction to Computer Systems

Spring and Summer: 12 units

This course provides a programmer's view of how computer systems execute programs, store information, and communicate. It enables students to become more effective programmers, especially in dealing with issues of performance, portability and robustness. It also serves as a foundation for courses on compilers, networks, operating systems, and computer architecture, where a deeper understanding of systems-level issues is required. Topics covered include: machine-level code and its generation by optimizing compilers, performance evaluation and optimization, computer arithmetic, memory organization and management, networking technology and protocols, and supporting concurrent computation. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course. Prerequisites: 15-123 (Grade of C or higher is required in the prerequisite)

Prerequisite: 15-122

18-220 Electronic Devices and Analog Circuits

Fall and Spring: 12 units

This course covers fundamental topics that are common to a wide variety of electrical engineering devices and systems. The topics include an introduction to semiconductor devices and technology, DC circuit analysis techniques, operational amplifiers, energy storage elements, sinusoidal steady-state response, frequency domain analysis, filters, and transient response of first- and second-order systems. The laboratories allow students to use modern electronic instrumentation and to build and operate circuits that address specific concepts covered in the lectures, including semiconductor devices and sensors, layout, operational amplifiers, filters, signal detection and processing, power converters and circuit transients. 3 hrs. lec., 1 hr. rec., 3 hrs. lab.

Prerequisite: 18-100

Corequisites: 33-107 and 18-202

18-231 Sophomore Projects

Fall

The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is conducting undergraduate research with a faculty member. Students do not need to officially register for undergraduate research unless they want it listed on their official transcripts. An ECE student who is involved in a research project and is interested in registering this undergraduate research for course credit on the official transcript may request to be enrolled in this course. To do this, the student should first complete the on-line undergraduate research form available on the ECE undergraduate student page. Once the form has been submitted and approved by the faculty member the student is conducting the research with, the ECE Undergraduate Office will add the course to the student's schedule. Typical credit is granted as one hour of research per week is equal to one unit of credit.

18-232 Sophomore Projects

Spring

The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is conducting undergraduate research with a faculty member. Students do not need to officially register for undergraduate research unless they want it listed on their official transcripts. An ECE student who is involved in a research project and is interested in registering this undergraduate research for course credit on the official transcript may request to be enrolled in this course. To do this, the student should first complete the on-line undergraduate research form available on the ECE undergraduate student page. Once the form has been submitted and approved by the faculty member the student is conducting the research with, the ECE Undergraduate Office will add the course to the student's schedule. Typical credit is granted as one hour of research per week is equal to one unit of credit.

18-240 Structure and Design of Digital Systems

Fall and Spring: 12 units

This course introduces basic issues in design and verification of modern digital systems. Topics include: Boolean algebra, digital number systems and computer arithmetic, combinational logic design and simplification, sequential logic design and optimization, register-transfer design of digital systems, basic processor organization and instruction set issues, assembly language programming and debugging, and a hardware description language. Emphasis is on the fundamentals: the levels of abstraction and hardware description language methods that allow designers to cope with hugely complex systems, and connections to practical hardware implementation problems. Students will use computer-aided digital design software and actual hardware implementation laboratories to learn about real digital systems. 3 hr. lec., 1 hr. rec., 3 hr. lab.

Prerequisite: 18-100

Corequisite: 21-127

18-290 Signals and Systems

Fall and Spring: 12 units

This course develops the mathematical foundation and computational tools for processing continuous-time and discrete-time signals in both time and frequency domain. Key concepts and tools introduced and discussed in this class include linear time-invariant systems, impulse response, frequency response, convolution, filtering, sampling, and Fourier transform. Efficient algorithms like the fast Fourier transform (FFT) will be covered.

The course provides background to a wide range of applications including speech, image, and multimedia processing, bio and medical imaging, sensor networks, communication systems, and control systems. This course serves as entry and prerequisite for any higher level course in the fields of signal processing, communications, and control. Prerequisite(s): 18-100

Corequisite(s): 18-202

Prerequisite: 18-100

Corequisite: 18-202

Course Website: <http://www.ece.cmu.edu/~ece290>

18-300 Fundamentals of Electromagnetics

Fall: 12 units

This course introduces electromagnetic principles and describes ways in which those principles are applied in engineering devices and systems. Topics include: vector calculus as a mathematical foundation for field descriptions, Maxwell's equations in integral and differential forms with associated boundary conditions as descriptions of all electromagnetic principles, quasistatic electric fields in free space and in materials, superposition for known charge sources, conduction and polarization, resistance and capacitance, charge relaxation, analytic and numerical methods for electric field boundary value problems, quasistatic magnetic fields in free space and in materials, superposition for known current sources, magnetization, inductance, magnetic diffusion, and analytic and numerical methods for magnetic field boundary value problems. 4 hrs. lec. Prerequisite: 18-220

18-310 Fundamentals of Semiconductor Devices

Spring: 12 units

This course replaced 18311 in Spring 2005. In this course you will receive an introduction to the operation and fabrication of the most important semiconductor devices used in integrated circuit technology together with device design and layout. At the end of the course you will have a basic understanding of pn diodes, bipolar transistors, and MOSFETs as well as some light emitting and light detecting devices such as photodiodes, LEDs and solar cells. You will also receive an introduction to the fundamental concepts of semiconductor physics such as doping, electron and hole transport, and band diagrams. In the laboratory you will learn how to lay out both bipolar and MOS devices and you will design small (2-3 transistor) circuits. The laboratory portion of the course emphasizes the relation between device design and layout and circuit performance. You will also experimentally evaluate the operation of amplifier and gate circuits fabricated with discrete devices. This course will give you an excellent understanding of the operation and fabrication of the devices which is necessary for high-performance analog and digital circuit design. 3 hrs. lec. (Note: the prerequisite is typically waived for MSE students who intend to pursue the Electronic Materials Minor.) Prerequisite: 18-220

18-320 Microelectronic Circuits

12 units

18-320 introduces students to the fundamentals of microelectronic circuits. The course will emphasize the analysis and design of basic analog and digital integrated circuits in preparation for further study in analog, digital, mixed-signal, and radio-frequency integrated circuit design. Additionally, students will learn to design and analyze microelectronic circuits using industry standard computer aided design (CAD) software. Topics to be covered include: MOSFET fabrication and layout MOSFET models for analog and digital design Analysis and design of digital CMOS logic gates Analysis and design of clocked storage elements (e.g., flip-flops, latches, memory cells) Delay optimization of digital circuits Circuit topologies for arithmetic and logical functional units Analysis and design of single-stage MOS amplifiers Frequency response characteristics of single-stage amplifiers Differential amplifiers and simple operational amplifiers Analog filters using operational amplifiers The course includes a lab component which will give students hands-on experience in the design and implementation of analog and digital circuits. Labs will employ both design using discrete, SSI, and MSI parts, as well as using CAD design tools. Prerequisite: 18-220 Corequisite: 18-240

18-331 Junior Projects

Fall

The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is conducting undergraduate research with a faculty member. Students do not need to officially register for undergraduate research unless they want it listed on their official transcripts. An ECE student who is involved in a research project and is interested in registering this undergraduate research for course credit on the official transcript may request to be enrolled in this course. To do this, the student should first complete the on-line undergraduate research form available on the ECE undergraduate student page. Once the form has been submitted and approved by the faculty member the student is conducting the research with, the ECE Undergraduate Office will add the course to the student's schedule. Typical credit is granted as one hour of research per week is equal to one unit of credit.

18-332 Junior Projects

Spring

The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is conducting undergraduate research with a faculty member. Students do not need to officially register for undergraduate research unless they want it listed on their official transcripts. An ECE student who is involved in a research project and is interested in registering this undergraduate research for course credit on the official transcript may request to be enrolled in this course. To do this, the student should first complete the on-line undergraduate research form available on the ECE undergraduate student page. Once the form has been submitted and approved by the faculty member the student is conducting the research with, the ECE Undergraduate Office will add the course to the student's schedule. Typical credit is granted as one hour of research per week is equal to one unit of credit.

18-340 Digital Computation

Spring: 12 units

In this course we will explore the techniques for designing high-performance digital circuits for computation along with methods for evaluating their properties. We begin by quickly reviewing number systems and digital arithmetic along with basic arithmetic circuits such as ripple-carry adders. We then focus on formal techniques and theory for analyzing the functionality, timing, power consumption, and chip area properties of these basic circuits and ones yet to be presented. From there, we move to more complex adders (carry-lookahead, carry-skip, carry_bypass, Wallace trees, and hybrid techniques) and multipliers (sequential, array, Booth, and others) along with various divider circuits. Floating point units are then built upon the concepts introduced for adder, multipliers, and dividers. Finally, we will investigate the design and implementation of digital filter circuits. For each circuit introduced, we will develop techniques for evaluating their functionality, their speed, power consumption, and silicon area requirements. In addition, we will utilize various CAD tools to design and evaluate most of the computation circuits discussed. After successful completion of the course, students will not only have an understanding of complex computation circuits, but subtle concepts that include hazards, metastability, false paths, inertial delay, sticky bits, clock skew/jitter, dynamic and static sensitization, and many others. 3 hrs. lec., 1 hr. rec. Prerequisite: 18-240

18-341 Logic Design and Verification

Fall: 12 units

This course is a second level logic design course, studying the techniques of designing at the register-transfer and logic levels of complex digital systems using modern modeling, simulation, synthesis, and verification tools. Topics include register-transfer level systems (i.e., finite state machines and data paths), bus and communication system interfacing (such as a simplified USB interface), discrete-event simulation, testbench organization, assertion-based verification and functional coverage. Design examples will be drawn from bus and communication interfaces, and computation systems, emphasizing how these systems are designed and how their functionality can be verified. A modern hardware description language, such as SystemVerilog, will serve as the basis for uniting these topics. Quizzes, homeworks and design projects will serve to exercise these topics. Prerequisite: 18-240

18-342 Fundamentals of Embedded Systems

Fall: 12 units

This practical, hands-on course introduces students to the basic building-blocks and the underlying scientific principles of embedded systems. The course covers both the hardware and software aspects of embedded processor architectures, along with operating system fundamentals, such as virtual memory, concurrency, task scheduling and synchronization. Through a series of laboratory projects involving state-of-the-art processors, students will learn to understand implementation details and to write assembly-language and C programs that implement core embedded OS functionality, and that control/debug features such as timers, interrupts, serial communications, flash memory, device drivers and other components used in typical embedded applications. Relevant topics, such as optimization, profiling, digital signal processing, feedback control, real-time operating systems and embedded middleware, will also be discussed. This course is intended for INI students. Anti-requisites: 18348 or 18349 Prerequisite: 18-240

18-345 Introduction to Telecommunication Networks

Spring: 12 units

This course introduces the fundamental concepts of telecommunication networks. Underlying engineering principles of telephone networks, computer networks and integrated digital networks are discussed. Topics in the course include: telephone and data networks overview; OSI layers; data link protocol; flow control, congestion control, routing; local area networks; transport layer; introduction to high-speed networks; performance evaluation techniques. The course also reviews important aspects of network security and widely used classes of Internet application and services, such as peer-to-peer, content delivery networks, and video streaming.

Prerequisites: (36-226 or 36-212 or 36-217) and 18-213

18-348 Embedded Systems Engineering

Spring: 12 units

Embedded computing applications far outnumber desktop computers, with billions of microcontrollers produced worldwide each year. Embedded systems vary tremendously, from the single 8-bit processor in a thermostat, to high performance processors in a digital camera, to dozens of networked processors in an automobile. Despite this diversity of applications, there are core technology and system-level skills needed by any embedded system designer that form the content of this course. The emphasis of this course will be at the system layer where hardware meets software, with plenty of hands-on experience at "bare metal" programming. Topics typically covered include embedded computing platforms (hardware, microcontroller instruction sets, software in both assembly language and C); interacting with the external world (analog I/O, digital I/O, serial ports, filtering, control, embedded networks); system-level engineering (design cycle, architectural patterns, peer reviews); real-time operation (timers, interrupts, concurrency, task switching, writing a simple RTOS kernel, scheduling); constraints and optimization (economics, power, performance); and a survey of techniques important for building systems that work in the real world (debug, test, robust design, dependability, safety, ethical/societal issues). Weekly hands-on hardware and software experiences with a 16-bit microcontroller module will tie directly to lectures to reinforce core skills. 4 hrs. lec., 1 hr. rec., 3 hrs. lab. Anti-requisites: 18342 or 18349

Prerequisites: 18-240 and 18-213

18-349 Embedded Real-Time Systems

Fall: 12 units

This practical, hands-on course introduces the various building blocks and underlying scientific and engineering principles behind embedded real-time systems. The course covers the integrated hardware and software aspects of embedded processor architectures, along with advanced topics such as real-time, resource/device and memory management. Students can expect to learn how to program with the embedded architecture that is ubiquitous in cell-phones, portable gaming devices, robots, PDAs, etc. Students will then go on to learn and apply real-time principles that are used to drive critical embedded systems like automobiles, avionics, medical equipment, the Mars rover, etc. Topics covered include embedded architectures (building up to modern 16/32/64-bit embedded processors); interaction with devices (buses, memory architectures, memory management, device drivers); concurrency (software and hardware interrupts, timers); real-time principles (multi-tasking, scheduling, synchronization); implementation trade-offs, profiling and code optimization (for performance and memory); embedded software (exception handling, loading, mode-switching, programming embedded systems). Through a series of laboratory exercises with state-of-the-art embedded processors and industry-strength development tools, students will acquire skills in the design/implementation/debugging of core embedded real-time functionality. Anti-requisites: 18342 or 18348

Prerequisites: 18-213 and 18-240

Course Website: <http://www.ece.cmu.edu/~ee349>**18-370 Fundamentals of Control**

Fall: 12 units

An introduction to the fundamental principles and methodologies of classical feedback control and its applications. Emphasis is on problem formulation and the analysis and synthesis of servomechanisms using frequency and time domain techniques. Topics include analytical, graphical, and computer-aided (MATLAB) techniques for analyzing and designing automatic control systems; analysis of performance, stability criteria, realizability, and speed of response; compensation methods in the frequency domain, root-locus and frequency response design, and pole-zero synthesis techniques; robust controller design; systems with delay and computer control systems; transfer function and state space modeling of linear dynamic physical systems; nonlinearities in control systems; and control engineering software (MATLAB). 4 hrs. lec., 1 hr. rec.

Prerequisites: 18-290 or 18-396

18-390 ECE CO-OP

Fall and Spring

The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is cooperative education, which provides a student with an extended period of exposure with a company. To participate, students must complete an ECE Co-op Approval form (located in HH 1115) and submit for approval. Students must possess at least junior status and have an overall grade point average of 3.0 or above. All co-ops must be approximately 8 months in uninterrupted length. If the co-op is approved, the ECE Undergraduate Studies Office will add the course to the student's schedule. Upon completion of the co-op experience, students must submit a 1-2 page report of their work experience, and a 1-2 page evaluation from the company supervisor to the ECE Undergraduate Office. International students should also be authorized by the Office of International Education (OIE). More information regarding CPT is available on OIE's website.

18-391 Noisy Signal Representation and Processing

Spring: 12 units

Please refer to the ECE webpage for a full description of this course.

Prerequisites: 18-202 and 36-217 and (18-396 or 18-290)

Course Website: <http://www.ece.cmu.edu/courses/items/18391.html>**18-401 Electromechanics**

12 units

This course provides a broadly based introduction to interactions between mechanical media and electromagnetic fields. Attention is focused on the electromechanical dynamics of lumped-parameter systems, wherein electrical and mechanical subsystems may be modeled in terms of discrete elements. Interactions of quasistatic electric and magnetic fields with moving media are described and exemplified. Unifying examples are drawn from a wide range of technological applications, including energy conversion in synchronous, induction, and commutator rotating machines, electromechanical relays, a capacitor microphone and speaker, and a feedback-controlled magnetic levitation system. 4.5 hrs. rec.

Prerequisite: 18-300

18-402 Applied Electrodynamics

Spring: 12 units

This course builds upon the electric and magnetic field foundations established in 18-300 to describe phenomena and devices where electromagnetic waves are a central issue. Topics include: review of Maxwell's equations, propagation of uniform plane waves in lossless and lossy media, energy conservation as described by the Poynting Theorem, reflection and transmission with normal and oblique incidence upon boundaries, sinusoidal steady state and transients on 2-conductor transmission lines, modal descriptions of waveguides, radiation and antennas. 4 hrs. lec.

Prerequisite: 18-300

18-403 Microfabrication Methods and Technology

Fall: 12 units

This course is a laboratory-based introduction to the theory and practice of microfabrication. Lectures and laboratory sessions cover fundamental processing techniques such as photo-mask creation, lithographic patterning, thin film vacuum deposition processes, wet-chemical and dry-etching processes. This is primarily a hands-on laboratory course which brings students into the microfabrication facility and device testing laboratories. Students will fabricate electronic and opto-electronic devices such as the metal-oxide-semiconductor (MOS) capacitor, the Schottky diode, the MOS transistor, the solar cell, and the light-emitting diode. An understanding of the operation of these building block devices will be gained by performing measurements of their electrical and opto-electronic characteristics. Emphasis is placed on understanding the interrelationships between the materials properties, processing, device structure, and the electrical and optical behavior of the devices. The course is intended to provide a background for a deeper appreciation of solid state electronic devices and integrated circuits. 2 lecture periods per week and a minimum of 4 laboratory hours.

Prerequisite: 18-310

18-410 Physical Sensors, Transducers and Instrumentation

Spring: 12 units

While modern electronic circuits have become largely digital, the physical world, and consequently, the electronic interface to the physical world remains fundamentally analog. Therefore, sensors, transducers, and the initial signal processing remain in the analog domain. Simultaneously, the commercial market place optimizes sensor technology based upon multiple attributes including cost, detectivity, size, speed, etc. In this course we explore both the many types of possible responses to various physical stimuli, as well as the instrumentation, electronic detection, signal conversion and signal processing techniques used to bring the physical event into the electronic world in a practical manner. This requires that we learn about the diversity of physical phenomena, materials and devices that can be used to convert the various forms of physical energy into electronic signals. Due to the significant diversity of physical phenomena the course requires reading from textbooks, the technical literature and patent literature. The course is taught via the case method with student participation via oral and written reports. The student should arrive with a strong interest in, and basic understanding of, physics, material science, chemistry and analog electronic circuits as taught at the sophomore and junior course level.

Prerequisites: 18-311 or 18-321 or 18-310 or 18-303 or 18-300 or 27-432

18-411 Computational Techniques in Engineering

Spring: 12 units

This course develops the methods to formulate basic engineering problems in a way that makes them amenable to computational/numerical analysis. The course will consist of three main modules: basic programming skills, discretization of ordinary and partial differential equations, and numerical methods. These modules are followed by two modules taken from a larger list: Monte Carlo-based methods, molecular dynamics methods, image analysis methods, and so on. Students will learn how to work with numerical libraries and how to compile and execute scientific code written in Fortran-90 and C++. Students will be required to work on a course project in which aspects from at least two course modules must be integrated.

Prerequisites: 15-100 and 21-120 and 21-122 and 21-259 and 21-260

18-415 From Design to the Market for Deep Submicron IC's

Spring: 12 units

The general objective of the 18-415 class is to introduce and analyze all major design-dependent trade-offs which decide about the IC product commercial success. This objective will be achieved via playing in the class an "imaginary fabless IC design house startup game"- a main class activity. In this game students will be asked to construct "business plans" for a startup fabless IC design house. Each team in the class will have to envision, as an IC design objective, a new product with a functionality, which is already provided by another existing IC product (i.e. by microprocessor). The envisioned product should provide a subset of functionality of the existing product but it should be "better" in some other respect (e.g. it could be less expensive to fabricate, faster etc.). To handle the above assignment, students in the class will be using skills learned in 18-322 as well as all legal sources of "industrial intelligence" typically available for the IC industry. They can also use the class teacher as a source of free consulting, as well as, they can ask for any sequence of lectures or literature sources which they will need to meet the class objectives.

Prerequisite: 18-320

18-418 Electric Energy Processing: Fundamentals and Applications

Spring: 12 units

This course provides an introduction to the fundamentals of electrical energy conversion and its use in several real-life systems. The course starts with a brief review of general mathematical and physical principles necessary for subsequent study of electrical energy conversion applications. This includes modeling, analysis, and control of general physical systems in time and frequency domain. Since the focus of energy conversion methods studied in this course is from electrical to mechanical systems, special attention is paid to electromagnetic theory. Rotating machines theory is developed and intuitively explained starting with Maxwell equations and analyzing general static and dynamic electromagnetic circuits. Power electronics methods are also introduced because most of modern electrical systems employ such methods. At this point, the necessary background is gained to analyze real life electrical energy conversion systems. We will focus on automotive, airplane, space station, and sea power systems. The main focus will be on operational principles and when appropriate stability issues of particular implementations. Time allowing, dynamic problems with interconnecting such systems will be briefly introduced and possibly studied by curious students in their course projects.

Prerequisite: 18-220

18-419 Semiconductor Device Applications - Optoelectronics and Nanoelectronics

Fall: 12 units

This course is designed to introduce important semiconductor optoelectronic devices and applications, such as light emitting diode (LED), solid state Laser, photo-detector, and solar cell, etc. It provides students with fundamental knowledge in optoelectronics as well as critical device design engineering. Developed on top of the fundamental knowledge covered in 18-310, the course begins with discussion on basic optics and device physics; it then focuses on operational principle, design engineering, and important applications of the devices. Special topics on novel nanoscale electronics and optoelectronics including nanowire, nano-particle light emitting and photovoltaic devices will also be discussed. In addition, an introduction to low-cost, flexible organic devices, e.g. display and solar cells will be presented. Prerequisite(s): 18-310

Prerequisite: 18-310

18-431 Undergraduate Projects - Senior

Fall

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18-432 Senior Projects

Spring

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18-447 Introduction to Computer Architecture

Spring: 12 units

Computer architecture is the science and art of selecting and interconnecting hardware components to create a computer that meets functional, performance and cost goals. This course introduces the basic hardware structure of a modern programmable computer including, the basic laws underlying performance evaluation. We will learn, for example, how to design the control and data path hardware for a MIPS-like processor, how to make machine instructions execute simultaneously through pipelining and simple superscalar execution, and how to design fast memory and storage systems. The principles presented in lecture are reinforced in the laboratory through design and simulation of a register transfer (RT) implementation of a MIPS-like pipelined superscalar in Verilog. Learning to design programmable systems requires that you already have the knowledge of building RT systems as is taught in the prerequisite 18-240, the knowledge of the behavior storage hierarchies (e.g., cache memories) and virtual memory as is taught in the prerequisite 15-213, and the knowledge of assembly language programming as is taught in the prerequisites. 3 hrs. lec., 3 hrs. lab.

Prerequisites: 18-240 and (15-213 or 18-213 or 18-243) and (18-320 or 18-340 or 18-341 or 18-348 or 18-349)

18-450 Digital Communications

Fall: 12 units

In this course, the communication problem will be introduced, and channel impairments such as noise, inter-symbol interference and fading will be described. Solutions to combat these impairments, based on digital communication theory, will be described. These will include signal space analysis, detection, equalization, coding and diversity. Throughout the course, the emphasis will be on discovering unifying ideas in transmission, rather than specifying the details of each application. 4 hrs. lec. This course was previously titled "Digital Wireless Communications"
Prerequisite: 18-391

18-472 Fundamentals of Electric Power Systems

12 units

Missing Course Description - please contact the teaching department.
Prerequisites: 18-202 and 33-107

18-474 Embedded Control Systems

Spring: 12 units

This course introduces principles for design of embedded controllers. In applications ranging from airplanes, to automobiles, to manufacturing systems, embedded computers now close feedback loops that were previously closed by mechanical devices or by humans in the loop. This course emphasizes practical insight into the tools for modeling and simulating these dynamic physical systems, and methods for designing the real-time software for embedded computers to control them. Lectures cover relevant theory and background from real-time systems and control engineering, including event-based and clock-based sampling, switching control, PWM (pulse-width modulation), PID (proportional-integral-derivative) design, state-variable feedback, state estimation, and methods for setpoint control and trajectory tracking. Basic embedded computing, sensor, and actuator technologies are reviewed, including microcontrollers, DC motors and optical encoders. In the laboratory, students use commercial tools for simulation and automatic code generation to design and implement embedded control system experiments. 3 hrs. lecture, 3 hrs. lab.
Prerequisites: (15-213 or 18-243) and (18-370 or 18-396)

18-482 Telecommunications, Technology Policy & Management

Spring: 12 units

This course provides a comprehensive introduction to basic principles of telecommunications technology and the telephone network, and the legal, economic, and regulatory environment of the telecommunications industry. Role of new technologies such as fiber, integrated digital networks, computer communications, and information services. Common carrier law and the economics of natural monopoly as the basis for regulation of the telecommunications industry. Issues of competition, monopoly and technical standards. Spectrum allocation and management. International communications and transborder data flow. Special emphasis on how the new technologies have altered and are altered by regulation. Junior or Senior standing required.
Prerequisite: 73-100

18-487 Introduction to Computer & Network Security & Applied Cryptography

Fall: 12 units

This course will introduce students to the fundamentals of computer security and applied cryptography. Topics include software security, networking and wireless security, and applied cryptography. Students will also learn the fundamental methodology for how to design and analyze security critical systems.
Prerequisite: 18-213

18-491 Fundamentals of Signal Processing

Fall: 12 units

This course addresses the mathematics, implementation, design and application of the digital signal processing algorithms widely used in areas such as multimedia telecommunications and speech and image processing. Topics include discrete-time signals and systems, discrete-time Fourier transforms and Z-transforms, discrete Fourier transforms and fast Fourier transforms, digital filter design and implementation, and multi-rate signal processing. The course will include introductory discussions of 2-dimensional signal processing, linear prediction, adaptive filtering, and selected application areas. Classroom lectures are supplemented with implementation exercises using MATLAB.
Prerequisite: 18-290

18-493 Electroacoustics

Fall: 12 units

This course provides an introduction to physical, engineering, and architectural acoustics. The course begins with a review of the wave equation and some of its solutions that are relevant to the propagation of sound from planar and spherical sources, and from arrays of simple sources. Lumped-parameter electrical circuit analogies are developed to describe mechanical and acoustical systems, leading to a discussion of the constraints and tradeoffs involved in the design of loudspeakers, microphones, and other transducers. The characteristics of sound in regular and irregular enclosures will be developed and discussed in the context of the acoustical design for rooms and auditoriums. The interaction of sound and man is also discussed, with introductory lectures on auditory perception and the acoustics of speech production, with applications in the areas of efficient perceptually-based coding of music and speech, and virtual acoustical environments.
Prerequisites: 18-220 and 18-290

18-496 Introduction to Biomedical Imaging and Image Analysis

Fall: 12 units

Bioimage Informatics (formerly Bioimaging) This course gives an overview of tools and tasks in various biological and biomedical imaging modalities, such as fluorescence microscopy, electron microscopy, magnetic resonance imaging, ultrasound and others. The major focus will be on automating and solving the fundamental tasks required for interpreting these images, including (but not restricted to) deconvolution, registration, segmentation, pattern recognition, and modeling, as well as tools needed to solve those tasks (such as Fourier and wavelet methods). The discussion of these topics will draw on approaches from many fields, including statistics, signal processing, and machine learning. As part of the course, students will be expected to complete an independent project.
Prerequisite: 18-290

Course Website: <http://andrew.cmu.edu/user/jelenak/Teaching/University/42403.html>

18-499 Internship

All Semesters

The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is an internship, normally completed during the summer. Students do not need to officially register for an internship unless they want it listed on their official transcripts. ECE students interested in registering their internship for course credit on their transcript may request to be enrolled in this course. The ECE Undergraduate Office will add the course to the student's schedule, and the student will be assessed tuition for 3 units. This process should be used by international students interested in Curricular Practical Training (CPT) or by any other engineering undergraduate wishing to have their internship experience reflected on their official University transcript. International students should also be authorized by the Office of International Education (OIE). More information regarding CPT is available on OIE's website.

18-510 Sensor Systems Design

Spring: 12 units

Please refer to the ECE webpage for a full description of this course.

Prerequisites: (18-300 and 18-320) or (18-300 and 18-491) or (18-310 and 18-320) or (18-310 and 18-491) or (18-320 and 18-491) or (18-300 and 18-421) or (18-310 and 18-421) or (18-320 and 18-401) or (18-320 and 18-402) or (18-401 and 18-421) or (18-402 and 18-421) or (18-401 and 18-491) or (18-402 and 18-491) or (18-320 and 18-419) or (18-419 and 18-491) or (18-421 and 18-491)

Course Website: <http://www.ece.cmu.edu/courses/items/18510.html>

18-513 RF Circuits and Antennas for Wireless Systems

Fall: 12 units

RF and wireless systems are ubiquitous. This course focuses on the transmission and reception of electromagnetic waves and their application in useful systems. RF and antenna measurements will be introduced. Antenna simulation tools will be discussed along with the design of several types of widely used antennas. The major portion of the course will be devoted to a project that will be addressed by a small team. The team will choose a project from several options. The team is responsible for clearly defining the engineering objectives; developing a prototype design, including necessary analysis and/or simulations; specifying and acquiring components; and finally building and testing the prototype.
Prerequisites: (18-320 and 18-300) or 18-402

18-525 Integrated Circuit Design Project

Fall: 12 units

This course is intended to provide the electrical and computer engineering student with IC design experience. It solidifies the theoretical background and practical skills gained in 18320 and 18422. The primary stress of the class will be on the IC design process as a whole. Such a process, seen as a sequence of design decisions, must lead to a design which optimizes a given objective function under a number of constraints. The optimum design must be achieved using a number of variables involving all levels of design abstraction and ranging between architecture choice and detail of the IC layout. Typical design objectives adopted in class designs will be IC performance (throughput, power, signal-to-noise ratio, clock frequency, gain-bandwidth, etc.) and typical constraints will be die size and minimum feature size. The second most important objective of the class is to mimic a large design team environment in which individual designers must: (a) communicate precisely and efficiently his/her ideas and (b) utilize any feedback provided by the "design environment." This objective will be achieved through class presentations given by each student and by stressing the importance of design documentation.

Prerequisites: 18-320 and (18-340 or 18-450 or 18-415 or 18-491 or 18-310 or 18-341)

18-540 Rapid Prototyping of Computer Systems

Spring: 12 units

This is a project-oriented course which will deal with all four aspects of project development; the application, the artifact, the computer-aided design environment, and the physical prototyping facilities. The class, in conjunction with the instructors, will develop specifications for a mobile computer to assist in inspection and maintenance. The application will be partitioned between human computer interaction, electronics, industrial design, mechanical, and software components. The class will be divided into groups to specify, design, and implement the various subsystems. The goal is to produce a working hardware/software prototype of the system and to evaluate the user acceptability of the system. We will also monitor our progress in the design process by capturing our design escapes (errors) with the Orthogonal Defect Classification (ODC). Upon completion of this course the student will be able to: generate systems specifications from a perceived need; partition functionality between hardware and software; produce interface specifications for a system composed of numerous subsystems; use computer-aided design tools; fabricate, integrate, and debug a hardware/software system; and evaluate the system in the context of an end user application. Senior standing is required.

Prerequisites: (18-370 or 18-320 or 18-491) and (18-349 or 18-341 or 18-348 or 18-340)

18-545 Advanced Digital Design Project

Fall: 12 units

In this capstone design project course, students will design and implement a large digital system with video output, sound output, and user input. The course will teach the technical skill to accomplish this, as well as enhance project planning and group management skills. To that end, students will participate in design reviews, weekly status reports, and final project presentations. The project will result in a working system implemented on an FPGA prototyping board. The completed projects will be shown in a public demonstration session at the end of the semester. Students should enter with a good grasp of computer architecture, Verilog programming, and hardware lab skills. Experience in FPGA programming, computer graphics, and/or VLSI design would also be useful. 4 hours lec., 24 hr. access lab

Prerequisites: 18-447 or {(18-340 and 18-341) or (18-340 and 18-348) or (18-340 and 18-349) or (18-340 and 18-320) or (18-341 and 18-348) or (18-341 and 18-349) or (18-341 and 18-320) or (18-348 and 18-320) or (18-349 and 18-320)}

Prerequisites: (18-340 and 18-341) or (18-340 and 18-348) or (18-349 and 18-340) or (18-340 and 18-447) or (18-341 and 18-348) or (18-349 and 18-341) or (18-341 and 18-447) or (18-348 and 18-341) or (18-447 and 18-348) or (18-447 and 18-349)

18-549 Embedded Systems Design

Spring: 12 units

18-549 Embedded Systems Design This course comprises a semester-long project experience geared towards the development of skills to design realistic and practical embedded systems and applications. Students will work in teams on an innovative project that will involve the hands-on design, configuration, engineering, implementation and testing of a prototype of an embedded system of their choice. Students will be expected to leverage proficiency and background gained from other courses, particularly with regard to embedded real-time principles and embedded programming. The project will utilize a synergistic mixture of skills in system architecture, modular system design, software engineering, subsystem integration, debugging and testing. From inception to demonstration of the prototype, the course will follow industrial project practices, such as version control, design requirements, design reviews and quality assurance plans. The initial lecture content will cover background material intended to complement the project work. The remainder of the course will consist of regular team presentations of key project milestones, current project status, a final project presentation and functional demonstrations of various subsystems, even as the entire prototype is being developed. Please refer to the course website for more information: <http://www.ece.cmu.edu/~ece549/>

Prerequisites: (15-410 or 18-320 or 18-491 or 18-447 or 18-370) and (18-348 or 18-349)

Course Website: <http://www.ece.cmu.edu/~ece549/>

18-551 Digital Communication and Signal Processing Systems Design

Spring: 12 units

This course provides the student with a rich, in-depth design and application hardware project experience in the areas of digital communications and/or signal processing systems using DSP hardware. Teams of students work on a semester-long project of their choice. Topics include: speech and music processing, digital communications, multimedia processing, data compression, data storage, wireless communications, CD, image and/or signal processing, etc. One month of introductory laboratories familiarize the students with DSP hardware and support software. Lectures address z-transforms, IIR and FIR filter design using MATLAB and DSP hardware, LPC and adaptive filters, channel coding, time and frequency multiplexing, short time Fourier and wavelet transforms, and spread spectrum techniques. 4 hrs. lec., 3 hrs. lab.

Prerequisites: 18-491 and (18-349 or 18-348 or 18-370 or 18-496)

18-578 Mechatronic Design

12 units

Mechatronics is the synergistic integration of mechanism, electronics, and computer control to achieve a functional system. Because of the emphasis upon integration, this course will center around system integration in which small teams of students will configure, design, and implement a succession of mechatronic subsystems, leading to a main project. Lectures will complement the laboratory experience with comparative surveys, operational principles, and integrated design issues associated with the spectrum of mechanism, electronics, and control components. Class lectures will cover topics intended to complement the laboratory work, including mechanisms, actuators, motor drives, sensors and electronic interfaces, microcontroller hardware and programming and basic controls. During the first week of class, each student will be asked to complete a questionnaire about their technical background. The class will then be divided into multi-disciplinary teams of three students. During the first half of the class, lab assignments will be made every 1-2 weeks to construct useful subsystems based on material learned in lecture. The lab assignments are geared to build to the main project. This course is cross-listed as 16-778 and 24-778. Students in other departments may take the course upon availability of slots with permission of instructor. Non ECE students may take the course upon availability of slots with permission of the instructor.

Prerequisites: (18-320 and 18-348) or (15-313 and 18-348) or (18-348 and 18-370) or (18-349 and 18-370) or (15-313 and 18-349) or (18-320 and 18-349) or (18-320 and 18-370)

18-610 Fundamentals of Modern CMOS Devices

Spring; 12 units

This course is intended to provide a foundation in device operation for circuit designers working in today's sub-micron CMOS. This course will also provide advanced understanding of CMOS technology for those interested in integrated circuit process technology and device physics. We review semiconductor device physics, including carrier dynamics and the basic equations of semiconductor device physics. The operation of the p-n junction diode is also reviewed. The course includes a description of integrated circuit fabrication technology and how it is used to fabricate CMOS devices. With this foundation, we then discuss the MOS capacitor (including its application as a varactor). The theory of the MOS transistor will then be developed, followed by a discussion of important phenomena in sub-micron devices such as: velocity saturation; breakdown; drain-induced barrier lowering; random dopant fluctuations, etc. The student will learn the relationship between device geometry, e.g. length, and fabrication, e.g. doping, and the corresponding circuit performance. The course will primarily be lecture-based, with some selected simulation exercises. Students are expected to be acquainted with the basic concepts of electrical circuits; electromagnetic fields at the level of a sophomore level physics course, and to have adequate preparation in mathematics (basic differential equations and MATLAB or similar applications). Prior coursework in device physics is helpful but not required for graduate students. Lecture: 4 hrs
Prerequisite(s): 18-310
Prerequisite: 18-310

18-615 Micro and Nano Systems Fabrication

Spring; 12 units

This is a new course intended to introduce students to the process flow and design methodology for integrated systems fabrication. The course will present this material through two paths. Lectures will be presented on the basic unit processes of micro and nanosystems fabrication: deposition, patterning, and etching. Lectures will draw on examples from: Semiconductor device fabrication; Microelectromechanical systems (MEMS) fabrication; Magnetic device fabrication, and; Optical device fabrication. Problem sets will be given based on this lecture material to allow students to quantitatively analyze certain process steps in detail. The second path for material presentation will be through a series of labs that allow students to design, fabricate and test an integrated device. These laboratories will be scheduled at regular meeting times, and will use research facilities within the ECE Department. This is a PhD level course. MS or senior students must obtain permission from the instructor to be registered.
Prerequisite: 18-310

18-617 Memory Devices and Systems

12 units

Missing Course Description - please contact the teaching department.

Prerequisite: 18-320

18-623 Analog Integrated Circuit Design

Fall; 12 units

Some form of analog circuit design is a critical step in the creation of every modern IC. First and foremost, analog circuits act as the interface between digital systems and the real world. They act to amplify and filter analog signals, and to convert signals from analog to digital and back again. In addition, high performance digital cell design (either high speed or low power) also invokes significant analog circuit design issues. The goal of this course is to teach students some of the methods used in the design and analysis of analog integrated circuits, to illustrate how one approaches design problems in general, and to expose students to a broad cross-section of important analog circuit topologies. The course will focus on learning design through carrying out design projects. Design and implementation details of wide-band amplifiers, operational amplifiers, continuous-time filters, phase lock loops and data converters will be covered. The course will focus primarily on analog CMOS, but some aspects of BJT design will be discussed. 4 hrs. lec. Prerequisites: 18-321 and senior or graduate standing.
Prerequisite: 18-421

18-632 Introduction to Hardware Security

Fall; 12 units

This course covers basic concepts in the security of hardware systems. Topics covered include active and passive attacks, reverse engineering, counterfeiting, and design of hardware security primitives (e.g., random number generators, physical unclonable functions, crypto-processors). Lab sessions will give students hands on experience with performing attacks, developing countermeasures, and implementing secure hardware building blocks. Students are expected to have basic knowledge of digital logic and Register-Transfer Level (RTL) design, but no specific background in security/cryptography is necessary.
Prerequisites: 18-240 and (18-341 or 18-447)

18-643 Reconfigurable Logic: Technology, Architecture and Applications

Fall; 12 units

Three decades since their original inception as a lower-cost compromise to ASIC, modern Field Programmable Gate Arrays (FPGAs) are versatile and powerful systems-on-a-chip for many applications that need both hardware level efficiency and the flexibility of reprogrammability. More recently, FPGAs have also emerged as a formidable computing substrate with applications ranging from data centers and mobile devices. This course offers a comprehensive coverage of modern FPGAs in terms of technology, architecture and applications. The coverage will also extend into on-going research investigations of future directions. Students will take part in a substantial design projects applying the latest FPGA platforms to compute acceleration. Register-Transfer Level (RTL) hardware design experience is required.

Prerequisites: 18-341 or 18-447

18-649 Distributed Embedded Systems

Spring; 12 units

Embedded computers seem to be everywhere, and are increasingly used in applications as diverse as transportation, medical equipment, industrial controls, and consumer products. This course covers how to design and analyze distributed embedded systems, which typically consist of multiple processors on a local area network performing real time control tasks. The topics covered will include issues such as communication protocols, synchronization, real-time operation, fault tolerance, distributed I/O, design validation, and industrial implementation concerns. The emphasis will be on areas that are specific to embedded distributed systems as opposed to general-purpose networked workstation applications. This course assumes that students already know fundamental topics such as interrupts, basic I/O, and uniprocessor scheduling that are commonly taught in introduction-level embedded system courses such as 18-348 and 18-349. Any graduate student who has not taken one of the pre-requisites is responsible for understanding relevant material necessary for this course. Additionally, all students are responsible for knowing or learning on their own intermediate-level programming in Java. Prerequisites: 18348 or 18349 and senior or graduate standing.
Prerequisites: 18-348 or 18-349

18-664 ULSI Technology Status and Roadmap for System on Chips and System in Package

Fall; 12 units

This course provides the necessary background for the state-of-the-art technologies utilized by the leading edge products covering full spectrum of market drivers from mobile platforms, microprocessors, game chips to the highest performance systems for enterprise solutions computing. We will present all key components of such systems, i.e., logic, analog/RF and embedded memories. Then we present the technology roadmap for the upcoming generations in terms of device architecture options for logic devices (FinFET, Nanowire and Tunnel FET) and memories (Phase Change Memory, Resistive RAM and Magnetic RAM/Spin-Transfer Torque RAM) from the device level all the way to the system level specifications. The last part of the class will be devoted to the system integration issues, namely 3-dimensional integration approaches. This course is designed for MS and PhD students from diverse areas: System/Hardware Design, Circuits and Devices/Nanofabrication and is aimed at bridging the gap among these areas. Graduate Standing (or permission from the instructor) is required for this course.

Prerequisite: 18-422

18-712 Elements of Photonics for Communication Systems

Fall; 12 units

Please see the ECE website for a full course description of this course. <http://www.ece.cmu.edu/courses/items/18712.html> Prerequisites: 18-300 and 18-310 and (18-402 or 33-439) and senior or graduate standing.
Prerequisites: 18-310 and 18-300 and (33-439 or 18-402)

18-715 Physics of Applied Magnetism

Spring: 12 units

In this course we address the physics of magnetism of solids with emphasis on magnetic material properties and phenomena which are useful in various applications. Various applications of magnetism are used to motivate the understanding of the physical properties and phenomena. The content of this course includes the origins of magnetism at the atomic level and the origins of magnetic ordering (ferro-, ferri-, and antiferromagnetism), magnetic anisotropy, magnetic domains, domain walls, spin dynamics and electronic transport at the crystalline level. The principles of magnetic crystal symmetry, tensors, and energy minimization are utilized to explore magnetic properties such as resonance, domain structures, magnetocrystalline anisotropy, magnetostriction and magnetoelasticity, and susceptibility. Phenomenological properties, such as the technical magnetization process, are used to describe mechanisms of coercivity, eddy current effects and losses, while energy minimization and relaxation are used to explain properties such as single domain particle behavior, memory mechanisms, magnetic aftereffects and thermal stability. Prerequisite: 18-300 or equivalent background in electromagnetic fields; Senior level solid state physics and materials, or the equivalent, and a senior or graduate student standing. Prerequisite: 18-300

18-716 Advanced Applied Magnetism

Spring: 12 units

Over the past decade, magnetism has once again become one of the dominant themes in material science and solid-state physics. Today, the development of new thin film recording media and the discovery of giant magnetoresistance have resulted in the amount of stored bits in a single disk drive to reach astronomical numbers. Rapid advances in spin-polarized electrical transport have brought to the horizon a new kind of electronics, called spintronics, with a new functionality based upon the spin of the carriers. The newly enriched magnetism brings unbounded technologic opportunities, yet full of challenges. This course will cover many of the important technological applications of advanced magnetism. The emphasis will be placed on how the basic principles and concepts are applied. The topics include: (1) Application and theory of spin dependent transport: CIP and CPP GMR devices, spin injection in semiconductors, spin LED, spin transistors, and spin current induced magnetic switching; (2) Engineering of the magnetic material properties for: thin film recording media, recording heads, magnetoresistive random access memory; (3) Thermally excited ferromagnetic resonance: mag-noise in magnetic devices, and thermally activated magnetization reversal; (4) Continuous and patterned magnetic films: magnetic bubble technology and patterned media; (5) Magnetostriction: magnetostrictive sensors; (6) Magnetic imaging techniques: magnetic resonance imaging (MRI), magnetic force microscopy (MFM), differential-phase-contrast microscopy (DPC), SEMP, and Kerr microscopy. 4 hrs. lec. Prerequisite: 18-715 or equivalent upon instructor's approval and senior or graduate standing. Prerequisite: 18-715

18-755 Networks in Real World

Spring: 12 units

18-755 is a graduate-level course that focuses on networks and their applications to various natural and technological systems. Specifically, this class delves into the new science behind networks and their concrete applications technological, biological, and social systems, as well as various design synergies that exist when looking at these systems from a cyber-physical perspective. By scope and contents, this is not just another class on "networks". Want to know how complex networks dominate our world? How communities arise in social networks? How group behavior dominates Twitter? How swarms of bacteria can navigate inside the human body? How patterns of interaction can be identified in hardware and software systems? Want to work on cutting edge projects involving systems and synthetic biology? Or social networks? Or networks-on-chip and internet-of-things? Then this class is for you! Course requirements consist of a few homework assignments, a semester-long project, and in-class presentations of relevant papers. By structure and contents, this class targets primarily the computer engineering and computer science students, but it also provides a valuable foundation for interdisciplinary research to students in related disciplines. Senior or graduate standing is required to take this course.

18-765 Digital System Testing and Testable Design

Fall: 12 units

For this course, time- and topic-indexed videos of lecture, homework, projects, etc. will be available from the online learning portal/website. In addition to these resources, two 1-hour live sessions are scheduled per week for recitation. Each student is strongly urged to attend one of these two sessions each week, either remotely or in the classroom on the Carnegie-Mellon Pittsburgh campus. This course examines in depth the theory and practice of fault analysis, test generation, and design for testability for digital ICs and systems. The topics to be covered include circuit and system modeling; fault sources and types; the single stuck-line (SSL), delay, and functional fault models; fault simulation methods; automatic test pattern generation (ATPG) algorithms for combinational and sequential circuits, including the D-algorithm, PODEM, FAN, and the genetic algorithm; testability measures; design-for-testability; scan design; test compression methods; logic-level diagnosis; built-in self-testing (BIST); VLSI testing issues; and processor and memory testing. Advance research issues, including topics on MEMS and mixed-signal testing are also discussed. 4 hours of lecture per week Prerequisites: 18-240 and 15-211 and (18-340 or 18-341) Senior or graduate standing required. Prerequisites: 15-214 and 18-240 and (18-340 or 18-341)

Course Website: <http://www.ece.cmu.edu/~ee765/>**18-771 Linear Systems**

Spring: 12 units

A modern approach to the analysis and engineering applications of linear systems. Modeling and linearization of multi-input— multi-output dynamic physical systems. State-variable and transfer function matrices. Emphasis on linear and matrix algebra. Numerical matrix algebra and computational issues in solving systems of linear algebraic equations, singular value decomposition, eigenvalue-eigenvector and least-squares problems. Analytical and numerical solutions of systems of differential and difference equations. Structural properties of linear dynamic physical systems, including controllability, observability and stability. Canonical realizations, linear state-variable feedback controller and asymptotic observer design. Design and computer applications to electronic circuits, control engineering, dynamics and signal processing. 4 hrs. lec. Pre-Req: 18-470 or 18-474 and Graduate standing in CIT or MCS. Prerequisites: 18-370 or 18-474

18-792 Advanced Digital Signal Processing

Fall: 12 units

This course will examine a number of advanced topics and applications in one-dimensional digital signal processing, with emphasis on optimal signal processing techniques. Topics will include modern spectral estimation, linear prediction, short-time Fourier analysis, adaptive filtering, plus selected topics in array processing and homomorphic signal processing, with applications in speech and music processing. 4 hrs. lec. Prerequisites: 18-491 or 18-791 and 36-217, and senior or graduate standing. Prerequisites: 36-217 and 18-491

Engineering Public Policy Courses

19-101 Introduction to Engineering and Public Policy

Spring: 12 units

This course examines the processes of public and private decision making and of policy formation, which shape the evolution of a technology and its impact on our society. Technology plays an important role in shaping our worlds. At the same time, social forces often play a central role in the evolution of a technology. A particular technology such as an automobile or computer is chosen to study technology and policy in context. Specific topics covered in the case of the automobile includes automotive design and manufacture, safety, pollution, fuel economy and their interactions. In each area, we discuss the technological and institutional issues, their interaction, the possible need for public policy and the factors that govern the policy. The course will involve several group problem-solving sessions. Corequisites: 33-106 and 21-121 and 21-120

19-102 EPP Sophomore Seminar

Fall: 3 units

The Sophomore Seminar has the objective of introducing the student to the interdisciplinary nature of Engineering and Public Policy problems. This is achieved through the use of case studies dealing with aspects of decision-making and ethics in policy issues which have a technological basis. Students are introduced to the technical and policy dimensions of these problems as well as to skills such as data collection and analysis, group work, and oral and written presentations. A few seminars by EPP graduates and faculty are occasionally included to give the student an idea of careers and EPP problems.

19-201 EPP Sophomore Seminar

Fall: 1 unit

The Sophomore Seminar has the objective of introducing the student to the interdisciplinary nature of Engineering and Public Policy problems. This is achieved through the use of case studies dealing with aspects of decision-making and ethics in policy issues which have a technological basis. Students are introduced to the technical and policy dimensions of these problems as well as to skills such as data collection and analysis, group work, and oral and written presentations. A few seminars by EPP graduates and faculty are occasionally included to give the student an idea of careers and EPP problems.

19-211 Ethics and Policy Issues in Computing

Spring: 9 units

Should autonomous robots make life and death decisions on their own? Should we allow them to select a target and launch weapons? To diagnose injuries and perform surgery when human doctors are not around? Who should be permitted to observe you, find out who your friends are, what you do and say with them, what you buy, and where you go? Do social media and personalized search restrict our intellectual horizons? Do we live in polarizing information bubbles, just hearing echoes of what we already know and believe? As computing technology becomes ever more pervasive and sophisticated, we are presented with an escalating barrage of decisions about who, how, when, and for what purposes technology should be used. This course will provide an intellectual framework for discussing these pressing issues of our time, as we shape the technologies that in turn shape us. We will seek insight through reading, discussion, guest lectures, and debates. Students will also undertake an analysis of a relevant issue of their choice, developing their own position, and acquiring the research skills needed to lend depth to their thinking. The course will enhance students' ability to think clearly about contentious technology choices, formulate smart positions, and support their views with winning arguments.

19-301 Decision Making Methods for EPP

Fall: 9 units

This course covers various economic, statistical, and decision analysis techniques used for examining complex decisions where technology, society, and policy interconnect. Topics covered include: estimation techniques, benefit-cost analysis, decision trees, dealing with uncertainty, risk perception and analysis, survey design and implementation, utility theory, heuristics and biases in inference and prediction, methods for combining information from different sources and dealing with conflicting objectives.

Prerequisites: 36-220 or 36-217

19-325 Technology and Policy Writing for Lay Audiences

Fall and Spring: 9 units

This course is designed to teach the fundamentals of persuasive, accurate writing about technical, highly specialized information for a general audience, based on an axiom attributed to Albert Einstein: If you can't explain it simply, you don't understand it well enough. Readings will be selected from writing style guides, and from nonfiction and science fiction literature. Course work will include the translation of data and journal articles into prose for a sophisticated general audience, as well as original writing.

19-350 SP TP: Research Methods & Statistics for Engineering & Public Policy Analysis

9 units

This course synthesizes concepts from economics, statistics, decision analysis, and other humanities and social science areas as they relate to analysis of technology and public policy issues. Students will focus on applying skills, tools, and techniques of social science to critically examine issues of current importance to society that have engineering systems at the core, and how public policy can be informed by the results of these analyses. Students will discover the relationship between formulating research questions considering a wide range of perspectives (e.g., political, ethical, social, economic, and legal aspects) and implementing the appropriate methods for answering them. The course will emphasize interpretation and communication of analysis results in written and oral presentation, especially to non-technical audiences. As a precursor to the EPP Project courses, the course also prepares EPP juniors for structuring real-world problems into a feasible work plan, and to deal with revising work plans as work proceeds.

19-351 Applied Methods for Technology-Policy Analysis

Spring: 9 units

This course synthesizes concepts from economics, statistics, decision analysis, and other humanities and social science areas as they relate to analysis of technology and public policy issues. Students will focus on applying skills, tools, and techniques of social science to critically examine issues of current importance to society that have engineering systems at the core, and how public policy can be informed by the results of these analyses. Students will discover the relationship between formulating research questions considering a wide range of perspectives (e.g., political, ethical, social, economic, and legal aspects) and implementing the appropriate research methods for answering them. The course will emphasize interpretation and communication of analysis results in written and oral presentation, especially to non-technical audiences. As a precursor to the EPP Project courses, the course also prepares EPP juniors for structuring real-world problems into a feasible work plan, and to deal with revising work plans as work proceeds.

Corequisites: 88-302 and 88-223 and 36-220 and 19-301

19-365 Water Technology Innovation and Policy

Spring: 9 units

Innovation in water technologies is necessary to confront profound water resource challenges facing countries around the world. Students successfully completing this course will be able to discuss the factors and conditions that drive innovation in the water sector. Students will begin by describing and classifying the historical drivers for innovation in water treatment, including technical, economic, and regulatory drivers. After an introduction to the fundamental principles of water treatment technologies, students will identify present day technology shortcomings and distill these into discrete design objectives. Students will then formulate and answer quantitative and qualitative questions that respond to these design objectives by leveraging their knowledge of engineering fundamentals, regulatory tools, and pricing policies. Comparing their own solutions with those proposed in the peer-reviewed academic literature in engineering and the social sciences, students will evaluate the technical feasibility, usability, and social desirability of proposed water innovations in developed and developing countries and summarize their findings in policy briefs.

Prerequisites: 19-201 or 19-101 or 12-100 or 06-100

Corequisites: 27-216 or 24-322 or 06-323

19-402 Telecommunications Technology, Policy & Management

Intermittent: 12 units

This course provides a comprehensive introduction to basic principles of telecommunications technology and the legal, economic, and regulatory environment of the telecommunications industry. Topics covered are: role of new technologies such as fiber, wireless, voice over packet, and broadband access; principles behind telecommunications regulation from common carrier law and natural monopoly to open access and interconnection; differences in the treatment of telecommunications versus information services. Also, mergers, antitrust, and the changing industrial structure of telecommunications; spectrum allocation and management; and international comparison of telecommunications regulations. Special emphasis on how the new technologies have altered and are altered by regulation.

Prerequisite: 73-100

19-403 Policies of Wireless Systems and the Internet

Intermittent: 12 units

This course will address public policy issues related to wireless systems, and to the Internet. It begins by investigating policies related to a wide variety of emerging wireless systems and technologies, including wifi computer networks, broadband to the home, broadcast radio and television, and satellite communications. This can include the government role in facilitating the creation of infrastructure, in advancing competition among broadcasters and communications service providers, in managing spectrum, and in protecting privacy and security. The course will then address Internet policy issues, which can include Internet governance and the domain name system, taxation, privacy and security, and intellectual property. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas.

19-411 Global Competitiveness: Firms, Nations and Technological Change

Fall: 9 units

Global Competitiveness introduces students to the fundamental principles surrounding global competitiveness and technological change in the 21st century. The course is broken into three sections. The first section introduces students to competing economic, sociological, and political science theories on the structures supporting technological change. The second section presents the contemporary literature on technological change. The concluding section leverages lessons from the preceding two sections to evaluate national innovation systems, and the factors that lead to national comparative advantage. Students should leave the class able to reflect competently on what the existing literature tells us about the factors influencing global technology competitiveness, and on how modern changes in the structures supporting innovation as well as technology itself may be changing the rules of the game for firms and for nations. The course is open to undergraduate juniors, seniors & graduate students.

19-424 Energy and the Environment

Intermittent: 9 units

This course will explore the relationships between environmental impacts and the utilization of energy through a series of case studies on topics of current interest. Such topics might include the use of renewable and non-renewable fuels for electric power generation; energy use for automobiles and other transportation systems; energy use for buildings and industrial processes; and environmental issues such as urban air pollution, ozone formation, acid rain, and global warming. The emphasis will be on analysis of energy-environmental interactions and tradeoffs, and their dependency upon engineering design choices, economic variables, and public policy parameters. Junior or Senior standing in CIT or permission of instructor.

19-425 Sustainable Energy for the Developing World

Fall and Spring: 9 units

This course examines the current state of the energy system in developing countries and the challenges these countries will face in sustainably meeting their energy needs in the 21st century. The following are examples of questions and issues we will cover throughout the semester. What is the current status of the energy system in the developing world? What is the role of energy in supporting economic growth and alleviating poverty? What are the future energy needs of developing countries? What are the challenges developing countries will face as they build/improve their energy systems? What technologies are available to meet the energy challenges in the developing world?

19-426 Environmental Decision Making

Intermittent: 9 units

This course will cover a number of topics in environmental decision making, including risk perception, risk communication, risk ranking, multi-attribute utility theory, decision analysis, the "precautionary principle," the economics of environmental externalities, commons dilemmas, cost-benefit analysis, the valuation of health and environmental amenities, discounting, intergenerational equity, environmental justice, and sustainability.

19-430 Civilian and Military Applications of Space

Intermittent: 12 units

An analysis of some specific defense and space policy issues is conducted. This analysis is abstracted from a study of the specific technologies involved. An assessment of the impact of technological advancement on the military capability, space policy and arms control issues is proposed. As the exploitation of high technology has a lot of ramifications, the course focuses on some areas carefully chosen, based on the recent events, to illustrate the extent of the impact and to permit as wide-ranging a discussion as possible. Those issues cover areas of advanced imaging and target recognition capabilities; the military exploitation of new physical principles; the development of new capabilities in space for military or civilian exploitation, and the convolution of these new capabilities with the increasing technological demands of arms control. In all examples, the interaction between techno-logical progress and needs for policy changes (or emergence of policy dilemmas) are emphasized.

19-440 Combustion and Air Pollution Control

Intermittent: 9 units

Formation and control of gaseous and particulate air pollutants in combustion systems. Basic principles of combustion, including thermochemical equilibrium, flame temperature, chemical kinetics, hydrocarbon chemistry, and flame structure. Formation of gaseous and particulate pollutants in combustion systems. Combustion modifications and postcombustion technologies for pollutant control. Relationship between technology and regional, national, and global air pollution control strategies. The internal combustion engine and coal-fired utility boiler are used as examples.

19-443 Special Topics in EPP: Climate Change Science and Adaptation

Fall and Spring: 9 units

This course will provide a background in climate change science and its application to adaptation efforts. Students successfully completing this course will acquire a solid understanding of the climate system, how climate is expected to change regionally, and how societies can adapt. Central components of the climate system that will be studied include Earth, heat budget, precipitation, the global circulation, and the mechanisms of weather. We will then survey global climate models, regional downscaling, and the process of detecting and attributing climate changes. This knowledge will be applied to explore regional climate impacts, including changes in droughts and floods, heat waves, hurricanes, Arctic climate change, and climate impacts on cities. For each type of climate change impact, adaptation efforts and barriers to adaptation will be discussed. Students will work on a team project to analyze selected regional climate adaptation efforts in more detail.

Course Website: <http://www.epp.cmu.edu/Users/special.html>**19-448 Science, Technology & Ethics**

Intermittent: 9 units

Technology has always been a pervasive force in society. But the last century, and especially the last 50 years have seen an unprecedented acceleration of the growth and permeation of technology. The central role of technology and engineering in the modern world calls for a reflective examination of the responsibility of those who develop, deploy and spread technologies as well as those who avail of them for various purposes. This course will explore one technology of recent origin in detail biotechnology. After examining the way people think about and deal with technological risk, the basic science behind the technology and the ethos of science and technology, the students will learn about the philosophical foundations of possible ethics for science and technology. Projects and discussions will explore how these foundations can be used to provide ways to frame important questions and develop an understanding of an ethic for the development and use of biotechnology.

19-451 EPP Projects

Spring: 12 units

Interdisciplinary problem-solving projects in which students work as leaders or members of project teams. Problem areas are abstracted from local, state and national situations and involve the interaction of technology and public policy, with different projects being chosen each semester. Oral and written presentations concerning the results of project studies are required. NOTE: All students will enroll in section A at first. During the 1st class, students will choose either project A or B. Those choosing B, will be moved into that section.

19-452 EPP Projects

Fall: 12 units

Interdisciplinary problem-solving projects in which students work as leaders or members of project teams. Problem areas are abstracted from local, state and national situations and involve the interaction of technology and public policy, with different projects being chosen each semester. Oral and written presentations concerning the results of project studies are required.

19-461 Invention & Innovation for Materials Intensive Technologies Part 1

Fall: 4.5 units

Two 4.5 unit classes that can be taken in sequence or as stand-alone mini's. Courses will be cross-listed between EPP and MSE. This course is intended to instill a sense of how technologies are conceived and brought to market. The students will be exposed to a variety of formalized invention and innovation processes/concepts and will be asked to complete projects that will pull from the full range of their engineering training. It is intended for seniors who are eager to creatively apply their learned knowledge skills, and who are interested in invention, innovation, and entrepreneurship. The first half (part 1 (19461), mini 1) will focus on the process of invention for devices and technologies that are enabled by materials functionality. This will start by providing historical context and addressing the questions "What is invention?" This will be followed by an assessment of various systematic methods by which the process of invention is practiced, with a specific focus on materials intensive devices and products. The second half of the course (part 2 (19462), mini 2) will examine innovation theory in the context of materials intensive technologies. Specifically, the concepts of incumbency, disruption, value chain, supply chain, funding models and paths to market will be addressed. In this class, significant time will be dedicated to covering the impact of international market and technology development.

19-500 Directed Study in EPP: Undergraduate

All Semesters

Students may do undergraduate research as one course for EPP technical elective credit, with an EPP faculty member, or on an approved project with a faculty member from another department. The research credits must be pre-approved by your advisor, and should result in a written product, one copy of which should be sent to EPP.

19-601 Information Warfare

Intermittent: 12 units

Information security is one major concern raised by the increasing use of computers in networks. In this course we first review, in some technical detail, the nature of the "threats". These include viruses and worms (their history and how they "evolved"), backdoor exploits, Trojan horses, buffer overflows, and the extent to which they imperil the information in computers. Then we discuss the use and limitations of firewalls in protecting computer networks. We also discuss intrusion detection and the problems associated with it. We review past and present cyberattacks, like Denial of Service attacks, viruses such as Melissa and I love you, and assess their implications. We analyze the origin of computer vulnerabilities which make those attacks possible and discuss the extent to which they could be reduced. Finally, we analyze the response to this situation at the national, security and international level.

19-606 Special Topics: Civil Systems Investment Planning and Pricing

Intermittent: 12 units

Economic framework for identifying and analyzing investment and operation options facing agencies and firms, (both in theory and in practice); economic efficiency, utilization, pricing, and investment; and multi-objective evaluation.

19-609 Public Policy and Regulation

Intermittent: 9 units

Regulations are a significant policy tool of government. How society and the economy will react to new regulations can be hard to predict. Unintended side effects sometimes occur resulting in costs exceeding estimates and/or benefits never being realized. This course will review the basics of regulatory policy and using historical examples, will explore the reasons why past regulations have succeeded and failed. The second half of the course will involve 2-3 detailed case studies. Quantitative methods will be used to evaluate several pending regulations for real-world clients from both government and industry perspectives. Prerequisites: Basic statistics, economics, and quantitative methods

19-611 Special Topics: Global Competitiveness: Firms, Nations and Technological Change

Intermittent: 12 units

This course introduces students to the fundamental principles surrounding global competitiveness and technological change in the 21st century. The past twenty years have seen dramatic changes in innovation ecosystems in the U.S. and internationally. Alone within the U.S., there has been a sharp decline in corporate R&D labs, matched by the global fragmentation of firm activities. At the same time growing linkages have been observed across institutional firms, government labs, and universities and national borders. These changes raise critical questions about the new rules of the game driving technological change in the 21st century. This course sheds insights into these questions through the lenses of competing economic, sociological, and political science theories on the structures supporting technological change. The course is broken into three sections. The first section introduces students to theories of the firm, bureaucracy, institutional economics, and social networks as competing frameworks within which to understand technological change. The second section presents the contemporary literature on the technological change, including creative destruction, dominate designs, industry life cycles, and networks of innovators. The concluding section leverages lessons from the preceding two sections to evaluate national innovation systems, and the factors that lead to national comparative advantage. Students should leave the class able to reflect competently on what the existing literature tells us about the factors influencing global technology competitiveness, and on how modern changes in the structures supporting innovation as well as technology itself may be changing the rules of the game for firms and for nations. The course is open to seniors and graduate students; also to juniors with instructor permission.

19-613 Industries and Technological Innovation: Positions, Paths and Progress

Intermittent: 9 units

This course provides an introduction to the exciting area of technological innovation. It will reflect an applied, industry oriented approach, and will emphasize empirical studies. The essence of the course revolves around a comparative analysis of how different industries develop, manage and disseminate new technologies. These will include software and the internet, automotive, semiconductors, biotech, chemicals, steel, among others. A wide range of issues will be covered, including what is product and process innovation, the role of intellectual property, coping with radical vs. incremental change, the management of knowledge, etc. The course will discuss specific industries and particular technologies, but no particular background in each technology is required for participation.

19-614 Environmental Life Cycle Assessment and Green Design

Spring: 6 units

Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This mini-course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software programs are used in assignments. A life cycle assessment project is required. Prerequisite: senior standing in engineering or permission of the instructor.

19-616 Case Studies in Sustainability Engineering

Spring: 6 units

The principles and tools of sustainability have yet to be applied on a large scale to solving real-world engineering problems. In this course, we explore the use of these principles and tools to various case studies.

Prerequisites: 19-622 or 12-714 or 19-614 or 12-712

19-622 Introduction to Sustainable Engineering

Fall: 6 units

Society has generally assumed that the earth's resources are limitless and wastes can be disposed of without serious consequences, but the validity of these assumptions is now being challenged. This course begins with an overview of the concept of sustainability and its history, including changing attitudes and values toward technology and the environment through the twentieth century. Key conferences and reports that helped define sustainability are reviewed. Models for population growth, global food production, and global water resources are then presented, and current problems of land use, urbanization, and energy and material resources are discussed. Overall, the course material provides a context for engineering decisions in the twenty-first century, which are quite different from decisions of engineers in the past. Prerequisite: senior standing in engineering or permission of the instructor.

19-623 Industrial Ecology and Sustainable Engineering Design

Fall: 6 units

This course uses the context established in 12-712 / 19-622 to explore the solution space of engineers in tackling basic problems facing human civilization. The course begins with the concept of a system, using the earth's life support systems as examples. The potential damage of conventional engineering decisions on these life support systems is discussed. Models of industry based on life sciences are then explored, and tools for sustainable engineering are presented. These tools include metrics of sustainability, principles of design for the environment, methods for pollution prevention, and use of mass and energy balances in the design of sustainable systems. Finally, the principles and tools of sustainable engineering are used to explore solutions to some of the most challenging problems identified in 12-712 / 19-622.

Prerequisites: 19-622 or 12-712

19-644 Medical Devices

Intermittent: 9 units

This course is an introduction to the engineering, clinical, legal and regulatory aspects of medical device performance and failure. Topics covered include phenomenological and mechanistic descriptions of processes such as wear, corrosion fatigue and fretting, in addition to the characterization of bone and other biological materials as it relates to device performance requirements, including biocompatibility. The course also involves case studies of orthopedic fixation devices and prostheses, pacemakers, heart valves and artificial organs. A major portion of the course is a final design project which involves the design of a new medical device or the redesign of an existing device.

19-648 Special Topics: International Climate Adaptation & Infrastructure Innovation

Spring: 6 units

Although an international problem, climate change will affect each country's critical infrastructure in diverse ways. This course will focus on understanding how international communities are adapting and innovating to reduce critical infrastructure risk. Students will be able to list and describe natural hazards affected by climate change, focusing on their impacts on natural and built critical infrastructure systems in physically, socially, and economically diverse countries. Students will then use cost-benefit analysis, the triple bottom line approach (physical, social, economic), and robust decision making to analyze, compare, and contrast different countries' responses. The class will culminate in a final paper and presentation on one country's approach to decision-making under uncertainty for adaptation. Learning Objectives: By the end of the semester, you should be able to: · Understand risk. · Define risk, hazard, vulnerability, exposure, adaptation, hazard mitigation, greenhouse gas mitigation. · Explain the link between some natural hazards and climate change · List 10 natural hazards and their impacts on the international community. · Analyze outcomes/impacts. · Predict how physically, socially, and economically detrimental a given natural hazard will actually be in different critical infrastructure systems. · Compare and contrast different adaptations to reduce risk. · Create recommendations for improving adaptation in an international community

19-650 Climate and Energy: Science, Economics and Public Policy

Intermittent: 9 units

The climate problem ties energy policy to the geosciences in one of the central environmental dilemmas of the new century. How much will the planet warm? Can we avert climate change without wrecking our economy? The political and economic stakes are high. We will first explore the science of climate change through study of simple physical models of the atmosphere and climate. Topics will include models of atmospheric radiation and of the vertical and latitudinal temperature structure of the atmosphere. In the latter half of the course we will focus on energy policy through study of the engineering and energetic constraints on industrial systems. Topics will include primary energy sources, energy conversion technologies, and energy economics and policy. Throughout the course we will alternate between lectures that survey of the key topics and detailed examples that require student involvement. Analysis of the energy flows and transformations will serve as a unifying theme for the course.

19-662 Special Topics: Technology and Development in China & India

Intermittent: 12 units

This course will explore the role of technology and economic development in India and China. It will open with three lectures that provide a theoretical framing for the course drawing broadly on the literature in economics and technical innovation. The balance of the semester will consist of a set of classes on the role of technology and innovation in India followed by a parallel set on China. The course will conclude with some cross-comparison between the experience and prospects in both nations. The course is open to undergraduates and graduate students. Students will be expected during each class to demonstrate mastery of individual concepts through in-class participation and occasional in-class quizzes on the assigned readings. Students will in addition choose a topic of interest to which to apply concepts in the form of three paper assignment across the duration of the course. These three paper assignments will include two mid-term assignments, one on India and one on China, and a final term paper building on the previous two papers to compare lessons across the two countries.

19-680 E&TIM Seminar on Innovation Management in Practice

Intermittent: 6 units

Innovation has been described as "the intersection of invention and insight, leading to the creation of social and economic value." Companies increasingly rely on innovation to establish and drive their success. Public policy makers see innovation as a critical driver for economic development. This course is an opportunity to learn about innovation management from those in the front lines. How are innovation opportunities identified? What are the challenges to realizing these opportunities, and how can the challenges be addressed? What roles are played by processes, technologies and the business environment, as well as by individuals in organizations? This course will feature speakers who drive innovation in a variety of settings, paired with readings from the innovation literature that will help frame the presentations and discussion.

19-681 Managerial and Engineering Economics

Intermittent: 12 units

The course emphasizes the application of economic principles (e.g., marginal analysis, supply and demand, competitive equilibrium, imperfect competition and monopoly) and fundamentals of engineering economics (e.g., quantifying costs and benefits, net present value, decision making under uncertainty) to managerial decision making. Topics include production and costs, elements of decision analysis, market mechanisms, pricing decisions, and information economics. The coverage of these topics fosters an understanding of the organization of firms and markets and firm decision making in the context of exploring, evaluating, and managing opportunities for technological innovation and diffusion.

19-682 The Strategy and Management of Technological Innovation

Intermittent: 12 units

The course on Strategy and Management of Technological Innovation prepares professionals with technical and scientific backgrounds for managing technology within an organization and the broader strategic decision-making required at the corporate level. This course teaches how an appropriate incorporation of technology and innovation into corporate strategy and management can lead the firm to achieve profitable and sustainable competitive advantage. It addresses the role of technology management in both emerging and established firms, and examines how all of the firm's activities, assets, and relationships must complement one another in order to capture value from innovation. The course will cover the frameworks, models and tools essential for those actively engaged in the innovation process within a firm and apply these to case studies illustrating their importance in technology industries.

19-687 Principles and Practices of R&D Management

Intermittent: 6 units

This course considers key issues and trade-off in R&D strategy and organization, paying attention to dynamic competitive contexts where technology plays a key role. These topics are treated assuming the perspective of the decision maker. It addresses typical problems of large, medium and small firms having a structured R&D and operating businesses where R&D is the source of competitive advantages. Although we will heavily focus on R&D, emphasis is placed on viewing R&D as a part (although, a key part) of the process of technological innovation; therefore, as an activity to be strongly and appropriately integrated with other functions to make innovation successful.

19-688 Innovation for Energy and the Environment

Intermittent: 12 units

Issues in energy and the environment may be framed in different ways. Engineers may describe a technical system while social scientists may choose policy terms. To these views, this course adds the business and innovation dimensions, which provide additional motivation for change in these dynamic areas. The class will explore opportunities for economic, environmental and social value creation for several cases, each of which has its own set of considerations for resources, stakeholder perspectives, business challenges and technical opportunities. The course will emphasize utilization of methods, tools and frameworks to describe and evaluate potential innovation opportunities in the energy and environmental sectors. Upon completion of the course, students should be able to evaluate the economic and environmental aspects of business decisions in these sectors, and know how to assess possible adoption paths, impacts and benefits.

19-692 Special Topics: Strategic Marketing and Product Planning for Tech Innovations

Intermittent: 6 units

The purpose of this master's level course is to develop the knowledge and skills needed to formulate marketing and product strategies for new technological product/service innovations in their market introductory phase. The course introduces the principles, concepts, frameworks and proven practices for analysis and strategic decision-making in an uncertain and constrained environment (i.e. when ample historical data and large budgets don't exist.) The course uses lectures, readings, group exercises, and an individual project with instructor feedback to achieve the learning objectives. The primary work in this course is hands-on application of the material by the student to create a strategic marketing plan for their own, approved product innovation idea with evaluation and feedback from the instructor. A customer-centric orientation is emphasized throughout the course. The course addresses strategic marketing decisions and activities including identifying value creation opportunities; generating and selecting innovation ideas; understanding the market, competition, customer needs and customer experience; segmenting, targeting markets; developing a positioning strategy and compelling customer value proposition; making marketing-mix decisions for product, pricing, route-to-market/distribution, and customer base development. The perspective of this course will be from a role of a strategic marketer, which is typically held by an entrepreneur/CEO, product manager, strategic marketing manager, product planning manager, new business development manager, or innovation manager. A syllabus and project description are available from the instructor.

19-693 Managing and Leading Research and Development

Intermittent: 12 units

Please refer to the description for ECE course 18-703. The EPP number is a cross listing of this same course.

Course Website: <http://www.ece.cmu.edu/courses/items/18703.html>**19-694 Special Topics: Leadership and Innovation Management**

Fall: 6 units

The attributes and skills of the contributors to innovation are important elements in the effectiveness of the innovation process and the success of the outcome. In this course, we will focus on these skills and attributes, with an emphasis on the leaders of innovation and innovative organizations. Selected literature, case studies, and guest lectures by leaders, as well as the instructor's own experience as Carnegie Mellon's eighth president, will be the sources from which the course will draw. Students will gain insight into the roles they may play in contributing to and leading innovation and organizations and the skills and attributes they will need for success.

19-697 Modern Prototyping Techniques

Spring: 6 units

Students in Modern Prototyping Techniques will explore a wide variety of tools and techniques for evaluating the feasibility of proposed new products, services, and solutions to business problems. They will work with an iterative process of: proposing solutions structuring tests to evaluate those solutions with prototypes creating the prototype efficiently and cost-effectively evaluating the effectiveness of the prototype learning from the experiment and iterating until an acceptable solution is found. There will be a strong focus on soliciting customer feedback as a basis for improvement and validation throughout the process. Students will learn prototyping techniques for addressing design, business, and technical problems. This will be a very hands-on course. Students will learn to use, and practice using, a diverse set of prototyping tools to complete their projects including computational, physical, visual design, and ethnographic tools.

19-699 Special Topics: Institutions Entrepreneurship and Innovation

Intermittent

Institutional environment and public policy greatly affect incentives determining the direction of entrepreneurial activity and innovation that are the engines of economic growth. In societies with poor institutions, entrepreneurial talent is mostly directed towards seeking rents rather than generating productive innovations. But even in modern capitalist economies entrepreneurial activity and innovation are strongly influenced by public policies, for example, those related to intellectual property rights. This course seeks to provide students with analytical frameworks that will enable them to understand how various formal and informal institutional arrangements and public policy decisions influence entrepreneurial activity and innovation and how this, in its turn, affects economic efficiency and growth potential of nations.

19-701 Introduction to the Theory and Practice of Policy Analysis

Intermittent: 12 units

This course reviews and critically examines a set of problems, assumptions and analytical techniques that are common to research and policy analysis in technology and public policy. Topics covered include the difference between science, trans-science and policy analysis, policy problems formulated in terms of utility maximization, issues in the valuation of intangibles, uncertainty in policy analysis, selected topics in risk analysis, limitations and alternatives to the paradigm of utility maximization, issues in behavioral decision theory, issues related to organizations and multiple agents, and selected topics in policy advice and policy analysis for the federal government. The objective is to look critically at the strengths, limitations and underlying assumptions of key policy research and analysis tools and problem framing and sensitize students to some of the critical issues of taste, professional responsibility, ethics, and values that are associated with policy analysis and research.

19-702 Quantitative Methods for Policy Analysis

Intermittent: 12 units

Economic framework for identifying and analyzing investment and operation options facing agencies and firms, (both in theory and in practice); economic efficiency, utilization, pricing, and investment; and multi-objective evaluation.

19-703 Survey, Design and Analysis

Intermittent: 6 units

Missing Course Description - please contact the teaching department.

19-704 Applied Data Analysis

Intermittent: 6 units

Instructor Revised Description as of 1-3-14: "This course will cover several statistical procedures, including procedures for basic statistics, multiple regression with interactions, logistic regression, multi-level models, and panel data, with an emphasis on hands-on data analysis."

19-705 Workshop Applied Policy Analysis

Intermittent: 6 units

The course is designed to provide experience in setting up, analyzing, and writing about policy problems of the type that are used in the EPP Part B qualifying exam. Over the course of the semester, the class works through six or seven policy case problems. Much of the work is done in small groups. The principal focus is on integrating the qualitative and quantitative aspects of the problems and on identifying and practicing general problem-solving strategies.

19-714 Environmental Life Cycle Assessment

Spring: 12 units

Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes using the ISO 14040 family of standards. This includes goal and scoping definition, inventory analysis, life cycle impact assessment (LCIA), interpretation, and guidance for decision support. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software such as MATLAB, Excel, and Simapro are introduced and used in assignments. A group life cycle assessment project consistent with the principles and tools of sustainability to solve real-world engineering problems is required.

Prerequisites: (12-421 or 12-706) and 12-712

19-716 Special Topics Science and Technology Policy, Analysis and Processes

Spring: 6 units

Science and technology policy is concerned with the allocation of resources for and encouragement of scientific and engineering research and development, the use of scientific and technical knowledge to enhance the nation's response to societal challenges, and the education of Americans in science, technology, engineering, and mathematics. This course will provide students with a better understanding of each of these areas and how decisions are made regarding science and technology at the national level and who influences those decisions. Upon completion of this course, students should have a deeper and more strategic understanding of how Washington works, how to analyze and present the results of science and technology policy analysis, and of long-term and emerging science and technology policy issues. Although the focus will be on the United States, these issues are as global as science and technology itself.

19-717 Introduction to Sustainable Engineering

Fall: 12 units

This course begins with an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the twentieth century. Models for population growth, global food production, and global water resources are then presented, and current problems such as land use, urbanization, and energy and material resources are discussed. Models of industry based on life sciences are then explored, and tools for sustainable engineering are presented. These tools include metrics of sustainability, principles of design for the environment, methods for pollution prevention, and use of mass and energy balances in the design of sustainable systems. Prerequisite: senior/graduate standing in engineering or permission of the instructor.

English Courses**76-100 Reading and Writing in an Academic Context**

Fall and Spring: 9 units

76-100 is an academic reading and writing course for multilingual students, especially those who are not native speakers of English or who consider English to be their weaker language. The course, designed as a prerequisite for 76-101, emphasizes reading comprehension strategies for reading a variety of text types in English (e.g., journalism, textbook selections, popular press arguments, and academic journal articles). Throughout the semester, students use these sources to write summaries and short position papers. The course introduces students to readers' expectations for North American rhetorical style at the sentence, paragraph, and whole text or genre levels. Within the course we discuss explicit genre and linguistic norms for writing in academic English so that writers can connect with their readers. Students who take this course qualify through an online placement test that is administered through the university prior to the fall semester. (All sections are offered MWF). Each 76-100 course is structured by the reading and writing objectives of the course as well as a vocabulary for writing in English, but some courses present different themes (or content) in their readings.

76-101 Interpretation and Argument

Fall and Spring: 9 units

76-101 introduces first-year students to an advanced, inductive process for writing an argument from sources. Because the course is based upon empirical research about professional academic writers, students will learn expert practices for authoring their own arguments that contribute to an existing community of authors. Because reading and writing are inseparable practices for academic writing, students will read a variety of texts so that they can explore and critically evaluate a single issue from multiple perspectives and from different disciplinary genres. Students will learn methods for summarizing, synthesizing, and analyzing arguments within that issue so that they may contribute an argument of their own. The course is also geared toward helping students understand the requirements of advanced college-level writing. Our students are typically very accomplished readers and writers, and we are eager to push their accomplishments toward greater excellence. For this purpose, students will build upon their composing knowledge by reflecting and thinking strategically as they plan, write, and revise their own texts. Ultimately, they will develop critical reading, rhetorical and linguistic practices for analyzing and producing texts within the context of an academic community. Each section of 76-101 is structured by the same objectives and core assignments. There is a core vocabulary and set of heuristics that all sections teach. However, students may find particular issues more appealing than others—we encourage students to pursue their interests, but we also ask that students engage any 76-101 course with intellectual curiosity. Due to the limits of our schedule, we are unable to meet each student's individual preferences for course topics, but we do offer a wide variety from which to choose. Section descriptions are posted at: http://www.cmu.edu/hss/english/first_year/index.html

76-143 Freshman Seminar: Creative Writing Matters

Intermittent: 9 units

This course will explore at least two of the meanings of the word "matters" as in "is of importance," and as in "things, concerns". Through reading and writing in various genres, students will discover and discuss how creative writing engages with the world around us while also learning some of the important techniques of writing creatively. The class will read a number of books by authors in various genres, and students will have the opportunity to interact with these authors through public readings and classroom visits. In addition, the class will take advantage of other literary events happening around Pittsburgh in order to further engage with places where writing comes off the page and engages with the world. Revision will be required and emphasized.

76-144 Freshman Seminar

Fall: 9 units

Topics vary by semester. Fall 2014: In the first chapter of one of the most notorious college novels, Stover at Yale (1912), Dink Stover imagines the glories that await him when he arrives: "They had begun at last? the happy, care-free years that every one proclaimed. Four glorious years, good times, good fellows, and a free and open fight to be among the leaders and leave a name on the roll of fame. Only four years, and then the world with its perplexities and grinding trials." The freshman of 2014, however, confront mounting student debt, accounts of gruesome college shootings, pressure to succeed from parents and peers, as well as the distractions of video games, college parties, and the internet. In this course we think about how we got here through the genre of the college novel, from the best selling classic, F. Scott Fitzgerald's *This Side of Paradise*, to Zadie Smith's *On Beauty*, to the best selling Pittsburgh based novel, *Wonder Boys*, by Michael Chabon.

76-145 Freshman Seminar

Intermittent: 9 units

Topics will vary by semester. Consult the course descriptions provided by the department for current offerings. Fall 2011: What does it mean to be Indian outside of India? How is it possible to "live in the hyphen" as both British and Pakistani? In this course we will look at the writings and experiences of South Asians (people from the Indian subcontinent), living in such places as the United States, Britain, the Caribbean, the Middle East, and East Asia, who construct what Salman Rushdie calls "imaginary homelands." We will examine the histories of migration and study how the experience of living between two continents has been theorized. In addition to examining the diaspora's past, the course will investigate present day South Asian Diaspora cultures including popular culture, film, music, dance, art, theater, and literature. Possible readings include works by V.S. Naipaul, Salman Rushdie, Jhumpa Lahiri, Hanif Kureishi, Meera Syal, Vijay Prashad, and Michael Ondaatje.

76-203 Pirates and Prostitutes in the 18th Century

Fall: 9 units

In this course, we discuss how sailors, pirates, and prostitutes changed the modern world. Blackbeard, Captain Kidd, "Black Sam" Bellamy, Calico Jack Rackham: these are just a few of the pirates who gained notoriety by terrorizing the seas in the 18th century. We explore this Golden Age of Piracy, investigating how these privateers created their own counter-culture. Equally important were the "ladies of the night" who eagerly anticipated the ships' return to port. Our course discusses how some of these women were able to amass fortunes off the pirates' plunder, and even became pirates themselves. We will examine various texts depicting sailors, pirates and their wenches, including paintings, cartoons, novels, songs about sailing, and plays. In doing so, students will be able to see how people dealt with various problems associated with privateers: sailors kidnapping loved ones, drunkenly tearing up the ports and spreading venereal disease, and enacting revenge against the Royal Navy's barbarity.

76-213 19th Century British Literature

Intermittent: 9 units

Topics vary by semester. Spring 2012: Women writers played an essential role in the construction of Victorian literary culture. In this course we will read novels, poems, and periodical extracts by a diverse body of nineteenth-century female authors as a means of better understanding women's historic and aesthetic impact on Victorian culture. While some of our authors are well known, like the wildly popular poet Elizabeth Barrett Browning, we will also encounter the 'lost' author, journalist, and controversial anti-feminist Eliza Lynn Linton. The writing of Victorian women exemplifies important social debates from the nineteenth-century. Social taboos such as divorce, suffrage, Bloomerism, children out of wedlock, and women in the workforce were all topical in Victorian culture. As the conflicted and introspective heroine of George Eliot's *The Mill on the Floss* reminds readers, the role of marriage as a woman's sole profession was becoming increasingly untenable in the modern era. Victorians were forced to ask what other function were women fit to occupy. From the Pre-Raphaelite poetry of Christina Rossetti, to the gothic horror of Emily Bronte's *Wuthering Heights*, "the woman question" served as a lightning rod for a variety of nineteenth-century cultural anxieties. The woman as deviant and criminal which we will encounter in Mary Elizabeth Braddon's *Lady Audley's Secret* was an especially controversial aspect of the female-dominated genre of "Sensation Fiction." Margaret Oliphant records in an 1867 review from *Blackwoods*: "What is held up to us as the story of the feminine soul as it really exists underneath its conventional coverings is a very fleshy and unlovely record. (See Dept. for full desc.)"

76-215 19th Century American Literature

Intermittent: 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Spring 2010: In this class, we will be reading many of the major works of Edgar Allan Poe, Nathaniel Hawthorne, and Herman Melville. Often described as America's Dark Romantics, these three authors are frequently read as reacting to the current of optimism and idea of human perfectibility that characterized antebellum America and the Transcendentalist movement. We will begin by reading most of Poe's short fiction and novellas and a number of his poetic and journalistic works. We will also read Hawthorne's two major novels *House of the Seven Gables* and *The Scarlet Letter*, as well as a number of his shorter works from *Twice-Told Tales*. The class will also look at a number of Melville's major works beginning with his first novel *Typee*, his short story collection *The Piazza Tales*, and culminating with *Moby Dick*. In addition to reading these canonical authors for their artistic merit, we will also consider the ways in which their works interacted with some of the prevailing ideas of their historical moments.

Prerequisite: 76-101

76-217 Contemporary American Literary & Cultural Studies

Intermittent: 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Summer 2010. It has been said that the teenager is the most free and least happy of all living beings. Given America's current obsession with youth culture, it's hard to imagine a time when the word "teenager" did not exist. However, this word came into being largely as a result of the post World War II boom in consumerism when advertisers needed a new way to define an emerging demographic group with its own disposable income and spending power. Through a survey of twentieth century literature that focuses on the teenage experience, we'll explore the changing meanings of young adulthood over the last one hundred years. What is the relationship between the invention of the teenager and modernist aesthetics? What characteristics were considered markers of young adulthood in the 1920's? In the 1950's? In 2000? How are the experiences of angst, anomie and the unfulfilled American dream connected to modern Western life through the teenage subject? How do tropes of individualism, rebellion, freedom and resistance connect the literature of teen angst with other genres of American literature? How has teen angst been both an impediment to and the inspiration for cultural resistance and social change? To answer these questions, we will compare texts such as Philip Roth's *Portnoy's Complaint*, Anzia Yezierska's *The Bread Givers*, J.D. Salinger's *Catcher in the Rye*, Margaret Atwood's *The Edible Woman*, Dave Eggers' *A Heartbreaking Work of Staggering Genius*, and Banana Yoshimoto's *Kitchen*. See English Department for full description.

Prerequisite: 76-101

76-221 Books You Should Have Read By Now

Intermittent: 9 units

It may seem more and more difficult to get a good classical, liberal education these days. The demands of professional training force many of us to skimp on our understanding of major artistic achievements. So, this class is for those people who should have read some of the best books around, but haven't managed to yet - books you should have read by now. Kurt Vonnegut's character Kilgore Trout sings the praises of Dostoevski's *The Brothers Karamazov*, (and the same thing might be said about *Crime and Punishment*) pointing out that it contains everything you need to know about life. He then ruefully adds that unfortunately that's not enough anymore. It may not be enough, but it might be a place to start. Each book will be considered in itself for whatever it might offer by way of understanding the world, the past, the present, ourselves and others. Finally we shall use the idea that literature is equipment for living as a way of understanding and evaluating our experiences. Or: what use is it to have read some of the so-called "great books" of the Western canon? A recurrent interest will be in improving our language ability in general as we consider various books of central importance to our cultural traditions.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-225 Topics in Rhetoric: Words and Numbers**

Intermittent: 9 units

Topics vary by semester. Spring 2014: For decades, communication researchers relying on stimulus-response theories associated a text with a single dominant stimulus evoking a single dominant response. This thinking widely influenced rhetorical understandings of language for decades as well. Today, rhetorical theories of language have discredited these behaviorist theories in favor of theories that see language as the constructors of situations rather than the effects of them. When speakers and writers use language, they resuscitate, enact, and perform worlds of experience from words. They create not only meanings but histories, identities, and social bids to initiate social change. This course introduces students to a theory and ontology of language study that is in keeping with language as a constructive activity. Students will learn to use software designed to analyze texts qualitatively and numerically from a constructive point of view. The software works as a microscope to help you see patterns of language use that escape the limited attention span of even the most painstaking of close readers. After learning how the software works, we will do exercises with small textual samples so that students can sharpen their powers of observing language across families of patterns. Students are encouraged to analyze the texts they love most — from literature, politics, journalism, to their favorite blog posts, tweets, and Facebook posts. (Full course description available on English department website).

76-227 Comedy

Intermittent: 9 units

We can't, of course, expect to come up with an absolutely complete definition of the comic, but for our purposes we can consider it as an embodiment of the opposite of "gravity." Comedy is characterized by its levity. This does not mean, of course, that it is any less "serious" than tragedy, even if or especially because it tends to favor the superficial over the profound. Indeed, if tragedy is adolescent, then the mature, adult mode is the comic, being more social and rational. A key characteristic of comedy is wit-or simply intelligence. Comedy involves a lot of pure play of the mind. It turns out that there have been a few notable attempts to help us understand just why comedy is the "social" genre beyond all others, why the comic attitude is the civilized, urbane, mature view of life. And we'll consider some of those theories while trying to understand why some things are comic and some are not. We'll consider several classical works of comic literature, beginning with Aristophanes, Shakespeare, and moving on to more recent examples, including some films.

76-232 Introduction to African American Literature

Intermittent: 9 units

The purpose of this course is to introduce you to diverse examples of literary, cinematic and musical expression centered on or created by the women and men of the African diaspora. This particular version of the class will concern itself with the very fraught and at times incommensurate relationship between politics, protest and art. The tragic deaths of Michael Brown, Renisha McBride and Eric Garner have illuminated the way Web 2.0 continues to play a crucial role in the organization of political protest (for instance through the hashtag #blacklivesmatter) as well as a representational war of position concerning how Brown, McBride and Garner were represented to the public sphere. Through a variety of media forms like the novel, television, cinema, music and the Web this class will take a historical view on our current politics of organization and representation starting with the Civil Rights and Black Power Movements of the 1960s and end roughly with the events in Ferguson, Missouri. You will read, listen or watch the works of James Baldwin, Amiri Baraka, Toni Morrison, Spike Lee, Aaron McGruder, Justin Simien, Ava DuVernay, Kara Walker and N.W.A. to name just a few of the artists we will discuss in this class. Along with these primary works this course will also introduce you secondary readings that will help you explore the historical, aesthetic and political issues that surround these works of art, give you a sense of how criticism functions and the multitude of forms criticism can take.

Prerequisite: 76-101

76-235 20th Century American Literary and Cultural Studies

Intermittent: 9 units

Topics vary by semester. Example, Fall 2010: 20th Century American Bestsellers: In this course we will work to construct a story about the United States and its literary tastes in the twentieth century by reading a selection of bestselling American fiction from the last 100 years. The class will introduce students to concepts central to the cultural study of popular texts, as well as a number of more and less familiar authors and novels. Readings will include only novels that appeared on yearly Publisher's Weekly top-ten bestsellers lists from 1900 to 1975. Winston Churchill's *A Far Country*, Edith Wharton's *The Age of Innocence*, Margaret Mitchell's *Gone with the Wind*, Sloan Wilson's *The Man in the Gray Flannel Suit*, J. D. Salinger's *Franny and Zooey*, and E. L. Doctorow's *Ragtime* are just a few of the novels that have shown up on this list. To complete our sketch of popular contemporary fiction, students will present on a bestseller from the last three decades and its reception. Moving through the wide range of texts that became bestsellers, from Wharton to Dan Brown or Stephen King, will allow us to consider whether Daniel J. Boorstin really got the whole picture when he said, "A best-seller was a book which somehow sold well because it was selling well." Course requirements will include a midterm exam, a presentation, and a final paper based on the presentation, as well as intensive reading.

Prerequisite: 76-101

76-237 Post Colonial Literature

Intermittent: 9 units

Topics will vary by semester. Consult the course descriptions provided by the department for current offerings.

76-238 Introduction to Media Studies

Intermittent: 9 units

Topics will vary by semester. Spring 2013: When we reflect on the role of media in our lives, we ought to consider both their meanings and functions. Media objects like advertisements, newspapers, and television shows all have various meanings for audiences, but they also serve central - and sometimes very different - functions in our economy, our democracy, and our everyday lives. The course will offer students a survey of various ways of understanding media objects, including aesthetic, formalistic, ideological, and economic approaches media. Students will practice their interpretation by encountering media objects like the classic 1939 propaganda film *The Middleton Family* at the New York World's Fair, simultaneously a scandalous love story, a reassuring American myth, a piece of self-serving public relations for the Westinghouse company, and a determined apologia for capitalism produced at the height of the New Deal era. Other visual media that we will analyze will include films like *Network* (Sidney Lumet, 1976) as well as smaller-scale objects like advertisements and internet "front pages." Interpretive and critical secondary texts will feature works by scholars like Theodor Adorno, Marshall McLuhan, John Berger, Raymond Williams, Noam Chomsky, and Mark Crispin Miller.

Prerequisite: 76-101

76-239 Introduction to Film Studies

Fall and Spring: 9 units

This course is an introduction to the history, technology, aesthetics and ideology of film. The main focus will be on the narrative fiction film, but we will also discuss documentaries, avant-garde work and animation. At the same time, we will be attentive to the ways in which our conceptual understanding of film has impacted the development of successive waves of visual media. The central organizing principle is historical, but there are a number of recurring thematic concerns. These include an examination of the basic principles and terminology of filmmaking, the development of film technology, the definition of film as both art and business, the history of film as an object of critical and cultural study, and the importance of film as the precursor of newer formats. The course has four key goals. First, to provide students with a solid grounding in the key issues and concepts of film studies. Second, to expand their ability to knowledgeably critique individual cinematic works and the relationship of those works to the larger culture. Third to provide students with experience in expressing those critiques in verbal, written and visual forms. Lastly, to provide them with an understanding of the central role of film history and film studies in the development of newer media.

Prerequisite: 76-101

76-241 Introduction to Gender Studies

Fall and Spring: 9 units

What is gender? What is sex? And how do we "perform" these identities in everyday life? Covering topics such as pornography, feminism, bros, queer theory, and transgender rights, this course will introduce you how power and inequality have historically and structurally impacted categories of gender in American society. We will read novels, scholarly texts, and even blogs in an effort to understand how gender intersects with other forms of identity (such as race, class, sexuality, ability, and nationality). Through a combination of class discussions, written essays, and short presentations, we will ultimately understand gender as a social construct that nonetheless is meaningful, personal, and significant for all members of society.

Prerequisite: 76-101

76-245 Shakespeare: Tragedies and Histories

Spring: 9 units

Would coming to CMU and not studying Shakespeare seem like going to the Sistine Chapel and not looking up? In 1878, Andrew Carnegie left his growing steel empire to sail around the world. Content to leave his business, he was not content to leave his 13-volume set of Shakespeare's complete works. He later wrote: "I have read carefully eleven of Shakespeare's plays during the spare hours of the voyage...They are such gems. I...feel as if I have made new friends, whose angel visits will do me good in days and nights to come?...everything has its 'environment,' and Shakespeare is the environment of all English-speaking men." Much has changed since Carnegie wrote those words, but many still hunger for an introduction to Shakespeare's Tragedies and Histories like this one. Our reading list will include hauntingly powerful plays such as *Hamlet*, *Othello*, *Macbeth*, *King Lear*, *Henry V*, *Richard II*, *1 Henry IV*, and *Henry V*. Students at the end of the course should expect to have a good grounding in the language, themes, and characters of Shakespearean Tragedies and Histories and perhaps more importantly be equipped to think carefully about Shakespeare's plays in relation to poetics, topical politics, and genre. In addition to regular short writing exercises of varying types, assignments will include one close reading paper, a longer research paper, and performance of a scene.

76-247 Shakespeare: Comedies and Romances

Fall: 9 units

Would coming to CMU and not studying Shakespeare seem like going to the Sistine Chapel and not looking up? In 1878, Andrew Carnegie left his growing steel empire to sail around the world. Content to leave his business, he was not content to leave his 13-volume set of Shakespeare's complete works. He later wrote: "I have read carefully eleven of Shakespeare's plays during the spare hours of the voyage? They are such gems. I?feel as if I have made new friends, whose angel visits will do me good in days and nights to come?...every thing has its 'environment,' and Shakespeare is the environment of all English-speaking men." Much has changed since Carnegie wrote those words, as Joss Whedon's film of *Much Ado About Nothing*, for example, can attest. But many still hunger for an introductory course like this one on "the Bard." Our reading list will include famous and exuberant plays such as *Much Ado*, *A Midsummer Night's Dream*, *As You Like It*, *The Merchant of Venice*, *Twelfth Night*, *Measure for Measure*, *Pericles*, *Cymbeline*, *The Winter's Tale*, and *The Tempest*. *Othello*, a tragedy, will help us give focused attention to questions of genre by way of counterpoint. Plots, jokes, conventions, and contexts - we'll discuss them all. Students at the end of the course should expect to have a good grounding in the language, themes, and characters of Shakespearean comedy and romance and perhaps more importantly be equipped to think carefully about Shakespeare's plays in relation to poetics, history, politics, and genre. In addition to regular short writing exercises of varying types, assignments will include one close reading paper, a longer research paper, and performance of a scene.

76-260 Survey of Forms: Fiction

Fall and Spring: 9 units

This is an introduction to the reading and writing of fiction designed as the first in a sequence of courses for creative writing majors and also as a general course for students wanting some experience in creative writing. Character development and the creation of scenes will be the principal goals in the writing of a short story or stories during the course of the semester —to a minimum of 15 pages. Revisions will be important and reading assignments will illustrate the different elements of fiction reviewed and practiced. A journal is required and two quizzes on the reading material.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>

76-261 Survey of Forms: Creative Nonfiction

Intermittent: 9 units

The National Endowment for the Arts defines "creative nonfiction" as "factual prose that is also literary." In this survey course, students will read a wide range of work that falls into this lively genre, including memoir, travel writing, the personal essay, and nature writing. Weekly writing assignments will give students the chance to work on short pieces of their own creative nonfiction.

Prerequisite: 76-101

76-262 Survey of Forms: Nonfiction

Intermittent: 9 units

According to The National Endowment for the Arts, creative nonfiction is "factual prose that is also literary." Memoir, the essay, and literary journalism are just three kinds of writing that fit into this very broad, very vital genre. While creative nonfiction often borrows techniques from fiction, such as narrative, scene, dialogue, and point of view, creative nonfiction is based on actual events, characters and places. What distinguishes creative nonfiction from journalism is that it conveys more than bare-bones facts and that language, analysis and narrative voice are integral parts of each piece. In this course, students will have the chance to read widely within the genre. Exercises and writing assignments will give students the chance to write their own pieces, so that by the end of the semester, everyone will have written four different kinds of creative nonfiction.

Prerequisite: 76-101

76-265 Survey of Forms: Poetry

Fall and Spring: 9 units

This course is designed to familiarize students with the elements of poetic craft through actively studying and practicing a range of poetic forms and principles. This is a discussion class in which we will examine both student work and published authors; there will be creative assignments as well as analytical ones. Near the end of the course, students will submit a portfolio of their own poems.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-267 The Short Story**

Intermittent: 9 units

Poe defined the short story as something that could be read at one sitting. While simple enough, the definition in fact suggests a concern with concentrated form and unified artistic effect. In a sense, the short story has been around as long as people have been telling each other tales, but as a literary form it came into its own in modern times, during the 19th century, and it continues to be produced in considerable numbers. For many readers one of the great features is the one Poe pointed to, it is short. People who have never finished a novel by Henry James must be legion. So, with the short story, we can experience something with genuine literary merit, in an accessible form. Concentration, of course, can bring issues of comprehension and often short stories can seem puzzling, or incomplete to the average reader. This class will attempt to develop our abilities to read with care and attention—and feeling—in order to make us better readers of any artistic text. The challenges of the short form turn out to be excellent opportunities for learning a lot, in a little space. We'll make use of several inexpensive anthologies, and look at one or two central writers (Hemingway and Borges) in more depth. The class will require the writing of a few short papers, engaging in online discussions on Blackboard, and three in class tests. Students can expect to develop their historical understanding of current experience and to gain an understanding of how to interpret and comment on significant pieces of fiction. They will become familiar with some key ideas about the nature of short stories in general and the interpretation of texts., and will engage in an attempt to develop a theory of the aesthetic nature of short fiction.

Prerequisite: 76-101

76-269 Survey of Forms: Screenwriting

Intermittent: 9 units

It is not so difficult to learn the format or even to master the style of the screenplay—the challenge lies in writing image-driven stories with believable dialogue, vivid characters, and a coherent, well-structured plot. To that end, students will view short and feature-length films, paying special attention to such fundamentals as character development and story structure. Students will read screenplays to see how scripts provide the blueprints for the final product, and write analytical papers. To gain experience and confidence, students will work on a number of exercises that will lead them toward producing a polished short screenplay by the end of the semester.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-270 Writing for the Professions**

Fall and Spring: 9 units

Writing in the Professions is a writing course specifically designed for juniors and seniors in all majors other than English. The course is appropriate for upper-level students in all CMU colleges, has no writing prerequisites, and assumes that you may not have had much college-level writing instruction past your freshman year. The basic idea of the course is to give you experience in developing the writing skills you will be expected to have as you make the transition from student to professional. The course will cover resume writing, proposal writing, writing instructions, the difference between writing for general and specific audiences, and analysis of visual aids in various texts. The course requires that students work both independently and in groups.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-271 Introduction to Professional and Technical Writing**

Fall and Spring: 9 units

Introduction to Professional and Technical Writing is designed specifically for declared majors in Professional or Technical Writing. The main work of the course is a series of five situation-based writing assignments spread over three broad and often overlapping areas - business/professional writing, media writing, and technical writing. Typical assignments include resumes, instructions, proposals, and adaptations of specialized information for non-expert audiences. At least one of the assignments will be a group project. As a final project, you'll create a portfolio of polished writing samples that you can use in applying for internships and employment. The range of assignments in the course is designed to give you experience with a variety of writing situations that professional writers frequently encounter. The assignments also reflect options for specialization that you may wish to pursue in future coursework and in your career as a professional writer. As you work through the assignments, you should learn both current conventions for the kinds of writing you'll be doing and a broadly applicable procedure for analyzing novel situations and adapting conventional forms (and creating new ones) to meet the unique demands of each new situation and task.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-272 Language in Design**

Fall: 9 units

Language in design is a professional communications course for designers. During your career as a designer, you will be expected to produce written documents to supplement and accompany your design processes and solutions. In this course, you will learn the conventions associated with the types of writing that designers most often have to produce on the job, such as proposals, memos, and reports. Additionally, you will prepare a job packet (including a resume, a cover letter, and a portfolio) that you can use as you begin your job search. You will also refine your ability to talk about your projects to both expert and non-expert audiences. Ultimately, this course aims to prepare you for the professional communications situations that you will encounter in your design career.

76-273 Presenting a Public Self

Fall: 9 units

Presenting your work and ambitions in public forums is a skill that you will be expected to demonstrate as you emerge from undergraduate studies and prepare to enter the commercial sector, graduate-level academic work or professional education in business, medicine or law. While such expectations exist, practice in this genre of writing, particularly in the personal statement, is not always readily available in existing coursework. "Presenting a Public Self" will introduce methods for developing and practicing your ability to communicate individual proficiencies and aspirations in written form, while bringing you in contact with a body of published work by public intellectual figures from the U.S. and other territories whose writing demonstrates an intertwining of personal narrative and public, professional identity, to engage readers of all stripes. Throughout the term you will practice writing in the public yet personal vein through assignments like: self-portrait essay, to cultivate a first-person voice, an op-ed essay, to practice balance in argument from the position of a burgeoning expert in your disciplinary area, and a personal statement, where you will learn to combine articulation of a personal narrative and professional competency to argue why you are a strong candidate for a particular opportunity. Reading selections for the semester will include work produced by your peers, as well as published writers whose work combines personal and professional spheres, ranging from texts like Paul John Eakin's *Living Autobiographically* to Mary Catherine Bateson's *Composing a Life* to Spencer Nadler's *The Language of Cells: A Doctor and his Patients*, amongst others.

Prerequisite: 76-101

76-276 Genre Studies

Intermittent: 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Fall 2012: Poe defined the short story as something that could be read at one sitting. While simple enough, the definition suggests a concern with concentrated form and unified artistic effect. In a sense, the short story has been around as long as people have been telling each other tales, to be sure, but as a literary form it came into its own in modern times, during the 19th century and it continues to be produced in considerable numbers. For many readers one of the great features is the one Poe pointed to: it is short. People who have never finished a novel by Henry James must be legion. So we can experience something with genuine literary merit, in an accessible form. Concentration, of course, can bring issues of comprehension and often short stories can seem puzzling or incomplete to the average reader. This class will attempt to develop our abilities to read with care and attention—and feeling—in order to make us better readers of any artistic text. The challenges of the short form turn out to be excellent opportunities for learning a lot, in a little space. We'll make use of several inexpensive anthologies, and look at one or two central writers (Hemingway, for example) in more depth. The class will require the writing of a few short papers, engaging in online discussions on Blackboard, and three in class tests.

Prerequisite: 76-101

76-294 Interpretive Practices

Fall: 9 units

This course introduces students to theories and practices of textual interpretation. Combining the approach of critical theoretical study with close textual analysis, we will produce our own interpretations of early modern literary texts, drawn from different genres - drama, poetry, nonfiction prose and the novel - while considering how theory informs our reading practices. Theoretical approaches include those that explore the role of the author, those emphasizing the workings of language, such as structuralism and post-structuralism, those that approach texts as embodied performances, as well as those that underscore the relationship between texts and contexts, such as feminism, Marxism, critical race theory, and postcolonial studies.

Prerequisite: 76-101

76-295 Topics in Russian Language and Culture

Fall: 9 units

Baba Yaga, Koschei the Immortal, the Firebird, Ivan the Tsarevich: Russian fairy tales brim over with monsters and magic, witches and devils, heroes and villains, princes and queens. In this course we examine a wide selection of these tales for what they can reveal about Russian culture's ethics, aesthetics, values and habits of mind. We discover these through four analytical approaches: structural, psychological, feminist and socio-political. Attention is paid to the ways in which fairy tales hold sway in literature and the fine arts from centuries past right through to the present day. Course requirements include primary and secondary readings, oral presentations, written essays, tests and participation in class discussions. No prerequisites; 9 units. For students with advanced Russian language skills, 3 additional units can be earned for additional meetings covering reading and writing tasks performed in Russian; permission of the instructor is required.

76-300 Professional Seminar

Fall: 3 units

This weekly, 3-unit seminar is designed to give professional writing majors an overview of possible career and internship options and ways to pursue their professional interests. Each session will feature guest presenters who are professionals working in diverse communications-related fields such as web design, journalism, public relations, corporate and media relations, technical writing, medical communications, and working for non-profits. The visiting professionals talk about their own and related careers, show samples of their work, and answer student questions. The course is required for first-year MAPW students and is open to all English undergraduates, who are urged to participate in their sophomore or junior years to explore options for internships and careers.

76-301 Internship

All Semesters

This course is designed to help you explore possible writing-related careers as you gain workplace experience and earn academic credit. You'll work on- or off- campus as an entry-level professional for 8-10 hours per week in a field of interest to you. You might, for example, intern with a local newspaper or magazine or radio or TV station, work for a publisher or political campaign, or do research and promotions for a non-profit agency associated with a cause you feel strongly about. Other possibilities include local hospitals, museums, theatre and other arts groups, software documentation firms and other groups needing technical writers and communications specialists, PR and ad agencies, law-related sites, and just about any place you can think of that requires writing and communication skills. Most of your class time for the course will be completed through work at your internship site a minimum of 120 hours (8-10 per week) over the semester for 9 units of credit. As the academic component of the course, you'll keep a reflective journal and meet periodically with the internship coordinator to discuss your internship and related professional issues. You will be responsible for finding your own internship, but it is recommended that you set up a meeting with the instructor to talk about your interests and what opportunities are open to you. You should do this before registration week.

76-302 Global Communication Center Practicum

Fall: 9 units

This practicum prepares students to tutor and conduct research in a communication center serving a range of disciplines. Students will be exposed to a variety of tutoring methods and gain experience analyzing and responding to academic genres from a range of disciplines. In addition, we will learn to support oral, visual, and collaborative modes of communication alongside more traditional written genres. All students in the practicum will be expected to design and complete a research project on an unfamiliar academic genre, tutoring methods, or online delivery of tutoring. Students should also expect to receive extensive feedback from faculty and peers on their tutoring methods. Texts will consist of a variety of readings on tutoring, responding to student writing, academic literacy, and communication across the disciplines.

Prerequisite: 76-101

76-306 Editing and Publishing

Fall and Spring

Note: Registration in this course is by permission only. Students must contact Prof. Costanzo directly. In this course students will work closely with the editors of Carnegie Mellon University Press to learn many of the facets of producing books. These range from business management and marketing to the elements of editing, book design, and production.

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-311 18th Century Literary and Cultural Studies**

Intermittent: 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Spring 2010: Writing in 1542 Bartolome de las Casas "observed that not a few of the people involved in this story had become so anaesthetized to human suffering by their own greed and ambition that they ceased to be men" and in 1972 Aime Cesaire notes that "colonization, dehumanizes even the most civilized man." Writing 400 years apart both men reflect an anxiety towards the social and economic effects of imperial expansion, which stands in sharp contrast to the pro-expansionist attitude of many including government officials and merchants. The aim of this course is to explore the competing understandings of Britain as a nation and an empire, which were expressed throughout the eighteenth and early nineteenth century. We will examine the influence of the British imperialism in the works of authors as diverse as Daniel Defoe, Jonathan Swift, Olaudah Equiano, Jane Austen, and William Makepeace Thackeray. In addition, we will explore theories of nationhood by Srinivas Aravamudan, Michael Hardt, Antonio Negri, and Edward Said.

Prerequisite: 76-101

76-313 19th Century British: Victorian Sensations

Intermittent: 9 units

Today if something causes a "sensation," it gives us a rush of excitement, a public uproar, a scandalous controversy, a terrifying threat, all magnified to us by electronic and global media. How should we think about, as opposed to merely reacting to, such sensations that preoccupy both public media and personal fears and fantasies? This course will show that "sensation culture" began in the 19th century and has been ever since a key part of mass culture up to the sensations of the present. At the center of very different public "sensations" there could be serial killers, astonishing scientific discoveries, daring visions of revolutionary transformation, revelations of devastating poverty and over-the-top luxury and wealth. Sensations powerfully affect the feelings, body, and imagination whether they are exploitative media concoctions or staggering revelations of the most serious social and natural secrets. We will read across this range of Victorian sensations—from Dickens' *Oliver Twist* and the 1% vs. the 99%, to the jolt produced by new theories of evolution (Darwin and Chambers), to alarming visions of revolution (Marx and Engels), to terrifying domestic secrets revealed in "sensation novels," to the advent of the serial killer (Jack the Ripper and Mr. Hyde), to anthropologies of disease and death. We will see all of these in relation to the new Victorian mass print media that constructed these and other "sensations" to contemporary readers. Readings in recent theory will help us raise conceptual issues about what makes a sensation and why some current cases (think epidemic, terror, climate change, vast inequality) help us grasp the history of producing and responding to painfully serious or pleurably spectacular "sensations." Prerequisite: 76-101

76-314 19th Century British Literary and Cultural Studies

Intermittent: 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Fall 2011: Changes in industry and education in the Victorian period affected women deeply; many women began to actively explore their options outside of the domestic arena, seeking access to education, careers, contraception, voting and alternatives to marriage and motherhood. These early feminists became known as "New Women," and from around 1870 to 1900, discourse by and about them flourishes. The New Woman both exhilarated and terrified. Was she a signifier of England's progressive health or was she a monstrous harbinger of the decline of proper English society? How did she both redefine and entrench gender ideology in the late-nineteenth century? We will read short stories, journalistic articles and several novels that address the New Woman, including Sarah Grand's *The Heavenly Twins*, Grant Allen's *The Typewriter Girl* and Bram Stoker's *Dracula*. Cultural narratives about gender, sexuality, science, industry and empire will inform our discussions. Prerequisite: 76-101

76-317 Contemporary American Fiction

Intermittent: 9 units

This course will overview the vast and varied field of contemporary American fiction. Starting with the end of Vietnam War (about 1973), we will try to define the succession of recent forms (such as minimalism, "K-mart realism" or "magical realism") and figure out some of the ways in which it represents American society and culture. Writers will range from Raymond Carver and Bobbie Ann Mason to William. Gibson and Alice Walker to Richard Powers and Jhumpa Lahiri. Prerequisite: 76-101

76-318 Communicating in the Global Marketplace

Intermittent: 9 units

In this day and age, some of the most exciting employment opportunities are with multinational and international corporations and non-profits. But are you prepared for the challenge of working with professionals from all over the world? Even as more people around the globe learn English, specific cultural values, beliefs, and assumptions continue to influence the way in which they communicate. Often, behind a foreign accent, we encounter an entirely different worldview. The same word or phrase in English might actually carry very distinct connotations for someone whose native language is French, German, Russian, or Japanese. Can we learn to anticipate, understand, and become sensitive to these connotations? How can we mend potential miscommunications that might arise due to these conceptual differences? This course is designed as an introduction to international professional communication. We will talk about the way in which culture influences communication, about the job of translators and interpreters, and about specific communicative norms for the global marketplace. We will look at many concrete example of communication in the international arena, acting as problem-solvers and communication consultants who are focused on understanding and designing plans of action for navigating communicative obstacles. We will also have the opportunity to speak with professionals who are experienced in the field, and we will cover case studies ranging from corporate business to global activism and advocacy. The requirements for this course include a take-home exam, a short paper, and a final project.

Prerequisites: 76-270 or 76-272 or 76-271

76-319 Environmental Rhetoric

Fall: 9 units

How people think and talk about the environment matters; it reveals what they value and shapes what they do. We will look at how competing discourses define man's relationship to the natural world, frame environmental problems, and argue for public action. As we compare the environmental rhetoric of naturalists, scientists, policy makers, and activists, we will trace an American history that has managed to combine mystical celebration with militant critique, and scientific research with public debate. Equally important, this course will prepare you to act as a rhetorical consultant and writer, studying how writers communicate the three "Rs" of environmental rhetoric: relationship with nature, the presence of risk, and the need for response.

Prerequisite: 76-101

76-321 History of the British Novel

Intermittent: 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Fall 2011: Poe defined the short story as something that could be read at one sitting. While simple enough, the definition suggests a concern with concentrated form and unified artistic effect. In a sense, the short story has been around as long as people have been telling each other tales, to be sure, but as a literary form it came into its own in modern times, during the 19th century and it continues to be produced in considerable numbers. For many readers one of the great features is the one Poe pointed to: it is short. People who have never finished a novel by Henry James must be legion. So we can experience something with genuine literary merit, in an accessible form. Concentration, of course, can bring issues of comprehension and often short stories can seem puzzling or incomplete to the average reader. This class will attempt to develop our abilities to read with care and attention—and feeling—in order to make us better readers of any artistic text. The challenges of the short form turn out to be excellent opportunities for learning a lot, in a little space. We'll make use of several inexpensive anthologies, and look at one or two central writers (Hemingway, for example) in more depth. The class will require the writing of a few short papers, engaging in online discussions on Blackboard, and three in class tests.

Prerequisite: 76-101

76-322 Global Masala: South Asians in the Diaspora

Intermittent: 9 units

This course looks at the writings and experiences of South Asians (people from the Indian subcontinent and its environs) living in such places as the United States, Britain, and the Caribbean. During the semester, we will read literary works alongside histories of South Asian immigrants and theoretical works about diaspora. In the process, we will consider such themes as identity, immigration, race, class and globalization. We will examine the histories of migration and study how the experience of living between two homelands has been theorized. In addition to examining diasporic literature, the course will investigate present day South Asian global cultures including popular culture, film, music, and dance. Possible readings include works by V.S. Naipaul, Hanif Kureishi, Meera Syal, Salman Rushdie, Jhumpa Lahiri, Nadeem Aslam, Mohsin Hamid, and Michael Ondaatje.

Prerequisite: 76-101

76-324 Topics in Rhetoric: Rhetoric and Leadership

Intermittent: 9 units

In this course, we will study communication strategies of effective leaders — people who seek to promote change in various professional, political, or cultural contexts. The main goals of the course are to understand rhetorical challenges that leaders face in different fields, to examine the language they use, and to learn (through theory, analysis, and practice) the most effective rhetorical strategies that can empower a leader. By drawing on the literature from management, organizational communication, psychology, and rhetoric, we will address a set of questions that include: (1) What makes an effective leader? (2) How do leaders use language and for what purposes? (3) What rhetorical strategies can be most useful to leaders to achieve their goals? (4) What is the role of creativity in leadership, and especially in the leader's use of language? We will mine the literature on leadership for theoretical insights on rhetoric. Students will be expected to lead discussions on readings, a midterm that synthesizes the readings, and a final project that reviews the literature and provides an annotated bibliography in some subfield of rhetorical leadership.

76-325 Intertextuality

Spring: 9 units

Topics will vary by semester. Fall 2014: What do we mean when we say that someone has "twisted" our words, or that our words have been "taken out of context"? Why is Martin Luther King Jr. best remembered for saying, "I have a dream," and not for saying, "War is the greatest plague that can affect humanity"? What are political "talking points" and how are they perpetuated? How does a claim (unfounded or not) become a fact? How does a fact become a myth? These are just some of the questions that we will consider. More specifically, this is a course in how meaning changes as texts created in one context and for specific purposes are repeated, cited, and used in other contexts and for other purposes, sometimes related and relevant, sometimes not. More technically, we'll be focusing on the rhetorical nature of intertextual discourse. Our goal will be to examine the ways that people of all kinds—including politicians, journalists, and scientists—strategically draw upon and transform the statements, arguments, and evidence of other people to promote their own viewpoints or purposes. We will begin by investigating scholarship that views language as an extended conversation in which people struggle to have their own voices heard, and other voices countered or even suppressed. Later, we will survey a number of studies that suggest how individuals and organizations recontextualize and reinterpret prior discourse for persuasive ends. More specifically, we will analyze how the micro-features of the language (for example, qualifications, evaluations, and attributions) are used to persuade audiences that certain assertions are (not) factual, that certain speakers are (not) authoritative, and that certain proposed actions are (un)desirable. Ultimately, you will conduct your own research on intertextual rhetoric on a topic of specific interest to your academic or professional goals.

Prerequisite: 76-101

76-327 Influential Women Writers

Intermittent: 9 units

Since long before the first autobiographical text in the English language? Margery Kempe's?women writers have opened new territory for prose narrative. This course will deal with some historical examples of this phenomenon: Marie de France's short fiction, Aphra Behn's *Orinoco*, and, of course, Jane Austen's novels. We will then focus on some twentieth-century writers with various kinds of influence. Virginia Woolf is known for technical experimentation, and Ursula Le Guin excelled in the male-dominated arena of science fiction. The innovative use of known forms is represented by Hilary Mantel's historical fiction and A. S. Byatt's remarkable *Possession*.

Prerequisite: 76-101

76-330 Medieval Literature

Intermittent: 9 units

Topics will vary by semester. Consult the course descriptions provided by the department each semester for current offerings. EXAMPLE: Fall 2011: Renaissance scholars sometimes promote the misconception that Shakespeare was the first writer to create characters with inner lives (rather than just social roles), that he was the inventor of the human, as Harold Bloom puts it. The varieties of writing—from the 700s to the 1400s—we will take up in this course will, I think, challenge that view. Some of the texts in which medieval men and women represented themselves are reflective, some are outrageous, some are charming, some are funny—all are populated by human beings we can recognize in spite of unfamiliar modes of presentation. We will explore both well-known fictions like *Beowulf*, *The Song of Roland*, Dante's *Inferno*, and Malory's *Morte Darthur*, and some not so well known. The lives of women in the Middle Ages will be a particular focus for the course. Students will also choose one twentieth-century fiction based on medieval materials to read and discuss with the class. Course requirements include regular attendance and participation in discussions, three brief papers and a final exam.

Prerequisite: 76-101

76-331 Renaissance Literary and Cultural Studies

Intermittent: 9 units

Topics will vary by semester. Consult the Course Descriptions provided by the Department each semester for current offerings. EXAMPLE: X-Files of the Seventeenth Century. Ghosts, monsters, prodigies, demons, and other strange phenomena: many of these so called "preternatural" occurrences were becoming the object of overlapping (and sometimes conflicting) forms of explanation during the seventeenth century. Whereas some of these phenomena could be explained philosophically - with reference to natural causes - others belonged to religious debate or seemed exclusively to exist in the imagination. Using a broad range of texts, we will examine the widespread interest in the preternatural in seventeenth century culture, exploring the political, religious, and ideological consequences of this fascination. Texts for the class will include images of natural "marvels" and "monstrosities," collections of "curiosities," plays by William Shakespeare and Ben Jonson, utopian fiction by Margaret Cavendish, selections from Edmund Spenser's *Faerie Queene*, seventeenth century crime pamphlets, philosophical texts by Francis Bacon, Robert Hooke's images from the microscope, readings in Renaissance and classical poetics, and various religious texts. Students can expect the reading for this class to be demanding but interesting. Several written assignments, a final exam, and conscientious participation in class discussion will be required.

76-332 African American Literature: The African American Crime Novel

Intermittent: 9 units

Topics will vary by semester. Spring 2014: The hard-boiled crime novel, developed in the 1920s, 30s, and 40s, depicts a world full of corruption and exploitation, where law does not necessarily equal justice. But while early hard-boiled crime fiction was typically written by white authors and focused on white protagonists, African Americans soon found the genre particularly appropriate to depict their long experience with systemic racism and economic exploitation in the U.S. In this class, we will explore how African-American authors like Richard Wright, Chester Himes, Walter Mosely, and Paula Woods appropriated the hard-boiled crime novel over the 20th Century to represent the effects of racism and economic inequality on the black community and American society and, in doing so, developed the genre into a unique expression of African-American history and identity. We will also examine how the African-American crime novel is taken up by other cultural mediums like film and, more recently, the graphic novel to create new ways of expressing the genre.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-333 African American Studies**

Intermittent: 9 units

Topics will vary by semester. Fall 2012: In this course students will explore "post-race" idealism within American literary and popular culture. With the election of President Barack Obama, the first African-American President of the United States, media pundits, historians and politicians marked the twenty-first century as the century we transcended "race" in American life. But what does it mean to be "post-race"? Where does this concept come from? Is this a good thing? Does being "post-race" mean the same thing to everyone? How does being post-race differ from multiculturalism? In order to explore these questions we will read or watch works such as Phillip Roth's *The Human Stain*, Jeff Chang's *Can't Stop Won't Stop: A History of the Hip-Hop Generation*, Barack Obama's *Dreams From My Father*, Toni Morrison's *A Mercy*, Paul Haggis' *Crash* and Timothy Chey's *Fakin da Funk*. We will also analyze contemporary print advertising, television commercials as well as explore theoretical and literary-critical approaches to the idea of race and post-race in American culture.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>

76-334 Literature of Wall Street

Intermittent: 9 units

It started with a financial panic that closed the New York Stock Exchange for ten days. One quarter of the nation's transportation companies went bankrupt, as did nearly 20,000 businesses. Unemployment reached 14%. Four years later it was officially declared a "depression." When did all of this happen? Was it 2009? Or the 1930s? No, it was the depression triggered by the financial panic of 1873. Out of this period, also known as the "Gilded Age," came a unique strain of American literature. Frank Norris's grisly tale of an overbearing dentist and his miserly wife, McTeague, Andrew Carnegie's autobiography, Upton Sinclair's iconic *The Jungle*, Edith Wharton's tragic love story *House of Mirth*, Charlotte Perkins Gilman's feminist utopian novel, *Herland*, William Dean Howell's capitalist satire, *The Rise of Silas Lapham*, Theodor Drieser's mournful *Sister Carrie*—all of these writings react to, and try to shape, the economy of a century ago. These novels, which were often critical of corporate capitalism, give us a rich and detailed picture of the last time in the US that Americans suffered under the kind of gap we have today between rich and poor. In the US today the top 1% controls 42% of the country's wealth, while the bottom 80% controls a mere 7% of the country's wealth. What can we learn about the present by reading the fictions of financial crisis and inequality in the past?

Prerequisite: 76-101

76-335 20th Century American: Mid-20th Century Fiction

Intermittent: 9 units

Topics will vary by semester. Consult the course descriptions provided by the department for current offerings. EXAMPLE Spring 2012: This course will survey American fiction from 1945 to 1980. "Post-1945" has typically been the catch-all to describe American literature after the modernist period, and has often been called "contemporary." However, that designation now seems inadequate: writers who became prominent in the immediate postwar era are historically removed, and writers arising since 1980 form a distinctly different generation, with a different sensibility. This course will account for the immediate postwar period, with the working hypothesis that we need to create a new construal of American literature and its recent past. It will look at authors such as Norman Mailer, Flannery O'Connor, Saul Bellow, John Updike, and Thomas Pynchon.

Prerequisite: 76-101

76-337 Intro to Ethnic American Studies

Intermittent: 9 units

This course will survey the major traditions of ethnic American literatures — including the African American, Latino/a, Asian American and Native American — from a comparative perspective that highlights the commonalities and differences among and within these groupings. In their indexing of other national traditions and forms, ethnic American literatures anticipate the challenge that globalization poses to the idea of an American literature bounded within the borders of the United States. We will be interested in identifying the wide range of literary strategies ethnic American authors employ in their explorations of multicultural identity, migration and sexuality. Reading will include a variety of contemporary poetry, fiction, drama and non-fiction prose works by authors such as Sherman Alexie, Gloria Anzaldúa, James Baldwin, Amiri Baraka, Lorna Dee Cervantes, Junot Díaz, Jhumpa Lahiri, Li-Young Lee, Audre Lorde, Toni Morrison and Leslie Marmon Silko.

Prerequisite: 76-101

76-338 Media and Film Studies

Intermittent: 9 units

Topics will vary by semester. Fall 2012: New media isn't new; old media isn't dead. The term "new media" itself presumes that a wholly original technology replaces another outdated one. This course will trace a history of media change from 1844 to the present day, or, roughly from the telegraph to the iPad, though we will dedicate the bulk of our attention to the mid to late twentieth century. Rather than accept a straightforward linear narrative of innovation, we will, instead, privilege use, reception, and context. The class will also explore various "dead media," technologies that got left behind in the march of progress towards the digital. By approaching the very idea of new media critically, the class intends to deepen students' understanding of both the historical and contemporary position of the digital media we rely upon to interact with the world around us. While the course readings will be comprised primarily of theoretical and historical approaches to media, we will also draw off many primary sources such as science-fiction, classics of American literature from writers such as Walt Whitman and Thomas Pynchon, as well as documents in which technical pioneers such as Alan Turing outline the form and function of concepts and devices that directly shape modern day computing. Since this course will cover multiple forms of media, students will be expected to develop methods to deal with the specifics of each medium. Students will keep media journals chronicling their interaction with various forms of media - new and old - and experiment with a small sample of digital archives and digital production software in order to complete a case study midterm project on an overlooked medium (or aspect of a medium) of their choice.

Prerequisite: 76-101

76-339 Topics in Film Studies

Intermittent: 9 units

In 1920, perhaps for the first time, youth began to be identified as having a distinct subculture. This phenomenon occurred in part because of the development of mass media, including popular books and magazines, movies, and recordings. These media provided both objects with which adolescents identified and hence defined themselves, and representations of the activities of youth to the rest of the population. This course will focus on films which have since the twenties performed these functions. It will pay particular attention to post-W. W. II youth subcultures in the United States and Britain such as the student-radical subculture or punk subculture. We will also look at the representations that the mass media have created of youth: from the "flaming youth" of the twenties to the juvenile delinquents of the fifties. While both movies and records are art forms, they are also commodities. They are products of what Adorno calls the "culture industry." In the 1950s, youth becomes a specific market for which a host of special products are created. These include genres of both movies and records, but also clothes, food, toothpaste. etc. While earlier products of large film studios and record companies aimed at the widest possible audience and tended to openly reflect mainstream values, the movies and records designed for teenagers tried explicitly to appeal to the values of a presumed youth subculture. Perhaps as a result—or perhaps for other reasons—some of these materials appear to be subversive of the dominant culture. A major question which this course will try to answer is whether youth culture has in fact been generally, or even occasionally, subversive, or whether it has served mainly to reinforce the dominant ideology.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-340 American English**

Spring: 9 units

Ever since the development of radio in the early 20th century, Americans have expected that we would soon all talk alike. The conviction that the media would make us all sound the same revived with the widespread adoption of television, starting in the 1940s, and the development of the internet in the 1990s led to worry about how soon we'd all be writing the same. But fears of the homogenizing effects of the mass media on American English have proven to be exaggerated: Americans still talk and write in many different ways. In this course we explore why this should be. Why don't we all speak alike? Why do we need variation in language? We will explore how regional and social dialects and varieties come to be and what their functions are, and you will learn how to hear, see, and describe varieties of language. We will also touch on American languages other than English. Documentary films and online materials about language will be the basis for another strand of the course, as we work together to explore how linguistic variety can best be represented and explained in non-technical ways, and in a variety of media, for the general public. Reading will be mainly in two books: *American English*, by Walt Wolfram and Natalie Schilling-Estes (2nd. edition), and *Language in the USA: Themes for the Twenty-First Century*, edited by Edward Finegan and John R. Rickford. There will be regular homework assignments, a midterm exam, and a final project.

Prerequisite: 76-101

76-341 Gender and Sexuality in Performance

Intermittent: 9 units

"Performance" describes a wide range of practices, from the everyday to the artistic. Gender and sexuality are key elements in everyday, political, and artistic performances, from the very personal - how you order a latte at Tassa D'Oro, tell a lover goodbye at the airport or comfort a crying child - to the very public - performing a Bach cello suite or an iconic King Lear, staging a demonstration against police violence or marketing a new app. How does everyday performance define gender and sexual identity? How do gender and sexuality define everyday performance? How does aesthetic performance - art, theater, film, digital media, poetry - intervene in the ways in which gender and sexuality are performed? Readings in theory at the intersection between gender studies and performance studies will help us explore these questions. We will read Judith Butler's work on gender as performative, Joseph Roach's work on the history of celebrity, Marvin Carlson's work on theater, and Rebecca Schneider's work on performing the past through historical enactment. We will also read and view a wide variety of cultural and artistic practices, beginning with the British 17th century up to the recent work of feminist and queer performance artists. Your written and spoken contributions to the class will, besides regular postings on the course materials and participation in class discussions, entail the investigation of an everyday, cultural, or aesthetic performance of your choosing. This course counts towards the Gender Studies Minor.

Prerequisite: 76-101

76-344 Studies in Print Culture

Intermittent: 9 units

Topics will vary by semester. Fall 2012: Censorship? Banned books? Book burnings? Could it happen here? In 20th-century America some of the most important films and books were banned, censored, produced in other countries, or written under an alias. But artists don't like to be silenced, and many of them found ways to tell their stories, regardless of the consequences. In this course we will examine three kinds of censorship: political censorship, racial censorship, and censorship based on sex/sexuality. We will read texts such as Kate Chopin's *The Awakening*, John Steinbeck's *The Grapes of Wrath* (and film), J.D. Salinger's *The Catcher in the Rye*, Harper Lee's *To Kill a Mockingbird* (and film), Kurt Vonnegut's *Slaughterhouse Five*, Toni Morrison's *Beloved* (and film), Richard Wright's *Native Son*, and Truman Capote's *In Cold Blood* (and film). We will also celebrate the American Library Association's banned book week, which is September 30th to October 6th.

Prerequisite: 76-101

76-345 Renaissance Studies

Intermittent: 9 units

In the age of Shakespeare and Milton (the sixteenth and seventeenth centuries), poetry, international politics, and theology were far more intertwined than they are today. While dedicated primarily to poetry, this course will investigate the implications of this intertwining in practice. Seeking to do justice to the true interdisciplinarity of Renaissance poetry, the course supposes that poetry and verse technique mattered so much in the period due to questions spanning art, politics, and theology of how power (verbal power, divine power, political power) should be represented. Biographically, many canonical poets we'll study in the course worked as ambassadors, representing power abroad (Wyatt, Sidney, Donne, Marvell). Many more poets including Shakespeare and Milton thematized diplomacy, in both its divine and more worldly forms ("angel," in fact, means "messenger"). Poetry too was seen in similar terms. As Coleridge would later write, poems were "the envoys or representatives of vital passion." Readings including Shakespeare's *Hamlet*, Milton's *Paradise Lost*, and John Donne's "The Ecstasy" will be introduced and contextualized through writers such as Pseudo-Dionysius, John Calvin, Thomas Hobbes, Alberico Gentili, and George Puttenham. Topics to be considered will include historical poetics, divinity, sovereignty, immunity, license, fidelity, craft, and accommodation. Assignments and class discussions will be occasions to practice historically-informed criticism; to compare conceptual structures within seemingly distinct domains of history and thought; and to articulate major fissures and changes in Renaissance angelology, diplomatic practice, and literary craft.

Prerequisite: 76-101

76-346 Angels and Diplomats -- Renaissance Poetry from Wyatt to Milton

Intermittent: 9 units

Topics will vary by semester. Spring 2014: Dedicated to political and religious poetry in the age of Shakespeare and Milton, this course has two main premises: (a.) that poetry, international politics, and theology were far more intertwined in the sixteenth and seventeenth centuries than they are today; and (b.) that angels and diplomats are good to think with. "Angel," in fact, means "messenger." The course will try to do justice to the true interdisciplinarity of Renaissance poetry, considering big questions involving secularization and poetry's relations to war and peace. For instance, are "all significant concepts of the modern theory of the state...secularized theological concepts"? Is war of humans' making (poesis) or of God's? If we treat angels, diplomats, and poems as early modern media, does the medium change the message? We will also consider questions of craft, technique, and poetics. One hypothesis is that verse technique mattered so much in the period due to the question of how power (verbal power, divine power, political power) should be represented and restrained. Biographically, many canonical poets we'll study worked as ambassadors, representing power abroad (Wyatt, Sidney, Donne, Marvell). Many more poets including Shakespeare and Milton thematized diplomacy, in both its divine and more worldly forms. Shakespeare considered his sonnets "written embassy[s]." Readings including Genesis, Shakespeare's *Hamlet*, Milton's *Paradise Lost*, and John Donne's "The Ecstasy" will be introduced and contextualized through writers such as Pseudo-Dionysius, John Calvin, Thomas Hobbes, Alberico Gentili, and George Puttenham. Further topics to be considered will include immunity (diplomatic and poetic), translation, license, fidelity, and accommodation. (See English department website for full course description).

Prerequisite: 76-101

76-347 American Literary and Cultural Studies

Intermittent: 9 units

Topics will vary by semester. Spring 2014: No one seems to know quite how to define contemporary American fiction. It's clear that fiction has changed since the 1960s and 70s, the heyday of postmodernism, but it's not clear what exactly characterizes more recent work that has come since. In this course, we will read a selection of contemporary American fiction from the 1980s to the present and try to get a sense of what is distinct about fiction in the contemporary moment. Some of the authors that we might read include Michael Chabon, Teju Cole, Junot Diaz, Jennifer Egan, Bret Easton Ellis, Jonathan Franzen, Chang-Rae Lee, Sam Lipsyte, Cormac McCarthy, David Foster Wallace, Colson Whitehead, and Meg Wolitzer. We will also look at critical definitions of postmodernism and the contemporary to see how they describe the fiction and to see if they match with the fiction we'll read.

Prerequisite: 76-101

76-349 20th Century American: The Lost Generation

Intermittent: 9 units

Before the Beat Generation there was the Lost Generation. Both moments of literary history have an important relevance for our time, and both produced many major literary works. The 20s, like the 50s and 60s, were marked by the effects of World War. Gertrude Stein seems to have started the whole generation naming fad with her comment to Hemingway, "You are the lost generation." Paul Fussell identifies the cultural effect of WWI as the production of 'irony' as the central quality of modern identity (Some Beat writers make a similar claim for the effects of WWII). This class is neither a prequel nor a sequel to the Beat writers class; it is related in theme but focused on different writers and texts. Students might consider taking this class as a point of entry to 'The Beat,' or might consider this class as a follow-on to 'The Beat' in order to understand more fully some of the central literary and historical issues of our time. In both cases we focus on the intersection between cultural change and major war. The Lost Generation class might include, for example, work by Stein, Hemingway, W.B. Yeats, Ezra Pound, T.S. Eliot, the major War Poets, F. Scott Fitzgerald, Robert Graves, Vera Brittain, and Evelyn Waugh.

Prerequisite: 76-101

76-350 History of Critical Ideas: Reading and Spectatorship

Fall: 9 units

Who is the reader of a text, the viewer of a painting or film, or the spectator of a performance? What does the medium in which a text is presented—the book, or film, or painting, or theatrical performance—have to do with how the text is received, consumed, contested, or appropriated, sometimes or often against the intentions of the author, painter, or performer? This course studies the long-debated problem of how readers or spectators respond to texts (in print, film, theater or painting) from ancient rhetoric and tragedy to contemporary mass culture. Aristotle, Plato, Longinus and other ancients theorized about audience response in terms of its danger or advantage to the polis; in that broad sense, the problem has always been political as well as psychological and aesthetic. Eighteenth-century thinkers formulated notions of 'beauty' and 'standards of taste' to measure audience response to poetry and visual art. Romantic writers developed psychologies of reading as symbolic interpretation. The rise of mass culture, on the other hand, links the politics of reading or viewing to questions of consumption and the market of cultural goods. Guided by recent critical theory as well as classic questions, we will ask how the reading or viewing subject is 'constructed' by the printed or filmic text; how institutions like schools control the process of interpretation; how individual readers 'appropriate' texts for themselves against their authors' intentions. Two shorter papers and one longer paper will be required for the course, in addition to a class presentation in the last two weeks of the semester.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-351 Rhetorical Invention**

Intermittent: 9 units

Rhetorical invention refers to the discursive process of inquiry, discovery, and problem solving, or how we decide what to say, what arguments to advance, and what means of persuasion to use. Although invention is centrally important to rhetoric—without which it becomes a superficial and marginalized study of clarity, style, and arrangement—from the Scientific Revolution and Enlightenment through the mid-twentieth century invention all but disappeared as a topic of rhetorical study under the pressure of the view that invention should be exclusively directed by deductive logic and the empirical method rather than rhetorical considerations such as audience or language. This view of invention fundamentally shaped modern thought and continues to influence the ways we think and communicate today. In this course, we'll begin by examining the repudiation of rhetorical invention in the development of modern thought before focusing on efforts to recover a rhetorical understanding of invention from the mid-twentieth century forward, surveying a variety of contemporary theories of rhetorical invention including those promoted by postmodern, posthuman, and digital rhetorics. The course is designed to explore the central importance of invention to contemporary rhetorical theory through a pairing of historical and contemporary readings.

Prerequisite: 76-101

76-353 Global Studies

Intermittent: 9 units

Topics vary by semester. Fall 2012: This course looks at the relationship between women and globalization. Globalization has been defined as the "creation of new and the multiplication of existing social networks and activities that increasingly overcome traditional political, economic, cultural, and geographical boundaries." What, then, are the roles and places of women in these new networks and activities? What is the function of the text-fiction, memoir, scholarly article or film—in describing these roles and places? This course will begin exploring these questions historically by theorizing women's relation to the nation in nationalist struggles. We will look specifically at the close connection between women and elements of tradition, including religion. Moving into the contemporary moment, we will examine the experiences of immigrant women and women in the global factory. As a way to interrogate our own assumptions, we will consider heated debates about global feminism. Throughout the course, we will think through the role of cultural representations in these issues. Readings will be drawn from around the world, and include theoretical works as well as literary and filmic representations.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-354 South Asian Literature**

Intermittent: 9 units

Topics vary by semester. Spring 2014: This course focuses on twentieth-century literature written in English from India, Pakistan and other parts of South Asia, as well as by people of South Asian origin. The course will begin by looking at literary representations that portray the struggle for decolonization and the trauma of partition. As we move forward to the contemporary period, we will examine the competing aesthetics of social and magical realism. We will then look back at India from the perspective of the diaspora, considering themes of identity, immigration and globalization from the perspective of South Asians writing in Britain and the United States. Texts might include works by Mulk Raj Anand, Bapsi Sidhwa, Amitav Ghosh, Salman Rushdie, Romesh Gunesequera, Arundhati Roy, Aravind Adiga, and Jhumpa Lahiri.

Prerequisite: 76-101

76-355 Leadership, Dialogue, and Change

Fall: 9 units

Leadership is often associated with the exercise of institutional authority or individual power. However the tradition of leadership based on dialogue shows us a powerful counter-rhetoric—one which organizes people to work together on complex problems through problem-posing, pragmatic inquiry, and the inclusion of marginalized perspectives. We will examine how this approach to leadership and change works in public voices of writers from Emerson and Martin Luther King, to the community organizing of an Alinsky, to the cultural critiques of African-American and feminist scholars such as Cornel West or bell hooks, and—equally importantly—in the ways ordinary professionals include voices and integrate social values into effective workplace writing, and the ways students call forth change on campuses. This introduction to the rhetoric of making a difference shows how its roots in American philosophical pragmatism created a focus on outcomes, not just ideals, and translated commitments into strategic rhetorical practices. In this course you will develop your own skills in writing and leadership by working as a "rhetorical consultant" to a campus or community group: learning how to investigate and define a shared problem, to develop a briefing book for deliberation, and to support inclusive decision making by documenting rival perspectives and options (see <http://www.cmu.edu/thinktank>). This portfolio project will also demonstrate your research skills and ability to support a problem-solving dialogue within an intercultural community or complex organization.

Prerequisite: 76-101

76-359 Planning and Testing Documents

Intermittent: 9 units

In this course, you will deepen your mastery of the following research skills associated with planning and testing documents: interviewing in context, retrospective interviewing, focus groups, surveys, and testing documents. In addition to specific research methods and skills, we will cover issues that pertain to all research methods: How many people do I need to include in my study? How should I select them? Are my results valid? Is what I think I'm finding out reliable? What are the ethical issues in my study? We will use a combination of lecture, discussion, exercises and projects to achieve these objectives. This course will be useful for any student who is interested in learning more about methods that are widely used in professions such as designing/writing for new media, technical writing, science and healthcare communication, public & media relations, policy and non-profit communication.

Prerequisites: 76-270 or 76-271 or 76-272 or 76-390

76-360 Literary Journalism Workshop

Spring: 9 units

Literary Journalism is non-fiction writing about the people and places in the world that might be overlooked by traditional journalism. Concerned more with those whose lives are outside of the traditional spot-light, literary journalism enriches our sense of who inhabits the contemporary world. Reading the stories of other lives can help us understand our own, by enlarging and deepening the context in which we understand our humanity. In this class, you will read a variety of professional literary journalism, and be asked to write your own. You'll have chances to interview people you know, and don't know, and write their stories, along with an assignment that invites you to capture your family history. You'll write about Pittsburgh places, and you'll learn how the stories of your own life can become literary journalism when you learn to contextualize them, and connect them to larger issues. The concerns and goals of Literary Journalism overlap with memoir, creative non-fiction, and magazine writing. The class is run as a seminar and demands high level of student involvement.

Prerequisites: 76-262 or 76-472 or 76-372 or 76-271 or 76-270 or 76-269 or 76-265 or 76-261 or 76-260

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>

76-361 Digital Humanities: Corpus Rhetoric

Intermittent: 9 units

This course investigates methods for analyzing rhetoric as it mainly exists in digital environments (e.g. blogs, newsgroups, homepages, political sites, Facebook and so on). The focus will be on verbal rhetoric, but students who wish to analyze visual rhetoric interactively with verbal rhetoric will be welcome to do so. In the first part of the course, we will review various methods for analyzing digital texts descriptively (viz., concordance, collocate and keyword analysis) and inferentially, through multivariate analysis (e.g., manova, factor analysis, discriminant analysis, cluster analysis). To learn these methods, in the first half of the course, we will use simple textual data sets supplied by the instructor. In the second half of the class, students will choose their own digital environments to analyze and they will be expected to write publishable-quality rhetorical analyses of these environments. To meet this expectation, students will need to do considerable background research in the digital environments they are studying.

76-362 Reading in Forms: Non-Fiction

Intermittent: 9 units

Whatever one's opinion of boxing, it endures - as a sport, and as a story that continues to grip the imagination of writers. To read about boxing is to read about race, poverty, violence, and the nature of sports, from the point of view of participant and spectator. As Joyce Carol Oates wrote in the foreword to her book-length essay on the sport, boxing forces us to contemplate not only boxing, 'but the perimeters of civilization - what it is, or should be, to be 'human.' We'll read fiction, essays, and memoirs, including Oates' book *On Boxing*, and the novel *Fat City*. We'll also view several movies, including *Raging Bull*, *The Fighter*, and *Million Dollar Baby*. Prerequisite: 76-101

76-363 Reading in Forms: Poetry

Intermittent: 9 units

Spring 2013: The Poet in America: selected readings in Bradstreet, Emerson, Poe, Whitman, Dickinson, Frost, Stevens, Lowell, and Williams; concluding with a consideration of Berryman's "Homage to Mistress Bradstreet." Particular attention will be paid to the poet's conception of his or her own role and of the sources and function of poetry. Fall 2012: This course will examine the role music plays as a theme and structural device in contemporary American poetry. The course will explore collections about musicians as well as collections written by musicians in genres that include Blues, Jazz, Rock and Hip-hop. Since class will be structured primarily around presentations, considered discussions and poetic responses, students should already be familiar with the major principles of poetry and be able to utilize them accordingly. Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-364 Reading in Forms: Fiction**

Intermittent: 9 units

While their names are often unknown, the voice of modern television is dominated by those writers called "show runners." Often billed as "Executive Producers," these men and women create their shows, edit their shows, are the lead writer for their shows, and almost always do a final edit on every script (written by them or one of their staff) you see broadcast. It might be said that no other class of artist dominates Los Angeles as much as show runners do. They move from one of their creations to another, often delivering material quite different in tone from one show to the next, but, if one digs deep, clearly originating from the same voice. This class will examine the work of a handful of show runners, spanning broadcast TV from the 80's (Steven Bochco & David Milch) to modern day (Ryan Murphy, Bryan Fuller, Bruno Heller, Shonda Rhimes, Barbara Hall). By contrasting their own work examples to each other, and then their work to other show runners, we'll come to a deeper understanding of the television art form. Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-365 Beginning Poetry Workshop**

Fall and Spring: 9 units

In this course students will read and discuss the work of contemporary poets, attend outside readings, critique classmates' poems, and write a significant number of their own poems. We will explore elements of craft through reading published work as well as completing in-class and take-home writing assignments. Though we will mostly be reading, writing, and discussing individual poems, toward the end of the semester we will move on to discussing (and writing) the poetic series. Prerequisite: 76-265

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-366 Beginning Fiction Workshop**

Intermittent: 9 units

Fall 2015: While science fiction, fantasy, and horror writing have often been marginalized or rejected outright in traditional publications and classes, in this class we will embrace these genres, exploring the essential skills of fiction writing "character, scene, description, detail, and so on" within the context of speculative fiction. We'll also study Young Adult fiction as it relates to these genres, and will read a range of speculative fiction for both adults and teenagers. As we create narratives set in imaginary worlds we will continually seek to create characters and plots that are convincing, moving, and meaningful, and will do so using elegant and evocative prose. Students will complete a number of writing exercises and at least two short stories or chapters and will submit a portfolio of work at the end of the semester.

Prerequisite: 76-260

76-367 Genre Studies

Intermittent: 9 units

Topics vary by semester. Fall 2013: The early part of the 20th century is often compared to the Renaissance as a time of massive literary innovation and production. This class will focus on a few novels by writers at the center of the invention of the modern literary world. Our goal will be to sharpen our reading skills and our understanding of a variety of experimental techniques in the novel. Henry James is often thought to be the source of modern ideas about fiction writing and was a powerful influence on all significant writers who followed him. D.H. Lawrence was a passionate critic of traditional novel forms, seeking a form more appropriate to the experiences of modern life. With his collaborator Ford Madox Ford, Joseph Conrad developed the technique known as impressionism, a style intended above all, as he said, to make us see. He is known for the complexity of his narratives and his formal experiments. James Joyce is regarded as having perfected all of the formal possibilities of the novel, effectively exhausting the form. The reading list will include books of this sort: Henry James: *The Bostonians*, Joseph Conrad: *Lord Jim*; D.H. Lawrence *Lady Chatterley's Lover*, James Joyce: *Ulysses*, Virginia Woolf: *To The Lighthouse* (not the actual list, but like that). Prerequisite: 76-101

76-372 News Writing

Fall: 9 units

In this introductory class, taught by a working journalist, students will learn the fundamental skills of reporting, writing and copy editing. We'll start with the basics - judging newsworthiness, conducting research and interviews, then organizing the information into a concise, clear, accurate and interesting news story. Because the key to learning to write effectively is to practice the necessary skills, class emphasis - and much of your grade - will be based on seven writing assignments involving current events and covering various types of news writing. Through readings, assignments and class discussion, we'll tackle questions such as: What makes a story newsworthy? How does a reporter decide which points to emphasize? What are effective techniques for a successful interview? How does a journalist turn pages of scribbled notes into a coherent news story? We'll do a lot of writing, but we'll also examine issues and trends affecting journalism today. We'll cover at least two live events and hear from local professionals about working in print, broadcast and public relations. We'll also look at how newer mediums - such as blogs, the internet, and cable news - shape and influence news reporting.

Prerequisite: 76-101

76-373 Argument

Fall and Spring: 9 units

This course is an introduction to the theory and practice of argument. The course begins with an overview of major theories of argument followed by consideration of a variety of topics in argument production, analysis, and evaluation, often applying the principles we study to specific cases in class. Students will each select a type or genre of argument-whether academic, practical, professional, or otherwise-upon which to focus their research throughout the course. Students will begin by developing short assessments of the value and relevance of major theories of argument to the type of argument they are researching, then develop their own approach to argument analysis and apply it to an example of that type of argument, before producing an original argument of the type they have been studying by the end of the course.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>

76-375 Magazine Writing

Fall: 9 units

In this course, we will read substantial, ambitious articles from a variety of magazines, considering their appeal to wide audiences. Students will write their own magazine articles, working with both their own autobiography and subjects they engage as field researchers. We will also be considering on-line, oral narratives, as a way to expand the concept of what a "magazine" is, and students will have the opportunity to create narratives for oral presentation. In this course, you should expect to develop your ability to create a good narrative, to gain experience in the field as interviewer and observer of the world, to become a better editor of your own work and the work of others, and to learn about aspects of culture from a wide variety of contemporary magazine writers. The class is run as a discussion with emphasis on student participation.

Prerequisites: 76-260 or 76-262 or 76-270 or 76-271 or 76-272 or 76-372

76-377 Rhetoric of Fiction

Intermittent: 9 units

Wayne Booth's book, *The Rhetoric of Fiction*, is one of the classic discussions of the ways in which fiction communicates, moves, or motivates us. It is a commonplace to assume that literature has a message, but it is still not at all clear just how an imaginative representation of the world does, or can, communicate. Booth had particular difficulty understanding how fiction could communicate a felt sense of life and value when there was doubt about narrative authority, or the 'reliability' of the author. So, postmodern fiction (from Joyce on) caused him problems. In an attempt to develop a postmodern rhetoric of fiction we shall be looking at texts that deal directly with issues of persuasion, or texts that seem directly to address the reader. Of particular interest will be texts that indirectly implicate the reader, and achieve a kind of implicit rhetoric even when they apparently frustrate normal expectations of communicative language (e.g. the apparent fact that the reader is also a character in Calvino's 'novel' if on a winters' night?). We'll consider the kinds of problems (and solutions to those problems) caused by excessive irony, by 'showing' rather than 'telling' and by the 'absent author,' in texts like *Madame Bovary*, *Notes From Underground*, *Portrait of the Artist as a Young Man*, etc.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-378 Literacy: Educational Theory and Community Practice**

Intermittent: 9 units

Literacy has been called the engine of economic development, the road to social advancement, and the prerequisite for critical abstract thought. But is it? And what should count as literacy: using the discourse of an educated elite or laying down a rap? Competing theories of what counts as "literacy" - and how to teach it - shape educational policy and workplace training. However, they may ignore some remarkable ways literacy is also used by people in non-elite communities to speak and act for themselves. In this introduction to the interdisciplinary study of literacy?its history, theory, and problems?we will first explore competing theories of what literacy allows you to do, how people learn to carry off different literate practices, and what schools should teach. Then we will turn ideas into action in a hands-on, community literacy project, helping urban students use writing to take literate action for themselves. As mentors, we meet on campus for 8 weeks with teenagers from Pittsburgh's inner city neighborhoods who are working on the challenging transition from school to work. They earn the opportunity to come to CMU as part of Start On Success (SOS), an innovative internship that helps urban teenagers with hidden learning disabilities negotiate the new demands of work or college. We mentor them through Decision Makers (a CMU computer-supported learning project that uses writing as a tool for reflective decision making.) As your SOS Scholar creates a personal Decision Maker's Journey Book and learns new strategies for writing, planning and decision making, you will see literacy in action and develop your own skills in intercultural collaboration and inquiry.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-385 Introduction to Discourse Analysis**

Intermittent: 9 units

Discourse analysis places a primary focus on how things are said; and this close attention to the details of "language in use" can offer insight into a variety of questions posed by researchers across the humanities and social sciences. In this course, we will examine the way discourse is itself a form of social action that plays a fundamental role in organizing social, cultural, and political life. In addition to becoming familiar with a variety of approaches and topics in the study of discourse, a major aim of the course is for you to develop the tools and skills needed to analyze actual discourse data. This will involve learning how to read transcripts and transcribe data at different levels of detail, learning how to ask questions about the data based on different analytic interests, and developing a vocabulary of scholarly terms and concepts that will allow you to comment on discourse features as you formulate interesting and persuasive claims. The first part of the course will involve assignments with shared data to develop fundamental skills. In addition, seminar participants will be responsible for selecting pieces of discourse for mini data sessions throughout the semester. For the final assignment, you will choose and analyze a piece of spoken or written discourse of interest to you. In the end, you should come away from the course with an ability to think critically about the way discourse operates in the world.

Prerequisite: 76-101

76-386 Language & Culture

Intermittent: 9 units

This course is an introduction into the scholarship surrounding the nature of language and the question of how language shapes and is shaped by social, cultural and political contexts. We will begin by studying important literature in linguistics and language theory, both to introduce us to how scholars think about language and to give us a shared vocabulary to use for the rest of the semester. We will then move into case studies and theoretical works exploring the intersections of language use, individual and group identities, and the exercise of power, in its many forms. In particular, we will focus on the relationship between language and culture by asking, in what ways does language influence and constitute social change? How is social change reflected by changes in the way we use language? Over the course of the semester, you will work on applying the knowledge and theoretical tools you gain to your own analysis of a linguistic artifact that you choose.

Prerequisite: 76-101

76-387 Narrative & Argument

Intermittent: 9 units

This course investigates information effects basic to the communication professional, generated primarily through structures of narrative and argument. We cover various genres supported by these structures, such as personal narratives, profiles, scenic writing, oral histories, information and instruction writing and policy argument. This course emphasizes both the production and the analysis of writing.

Prerequisite: 76-101

76-389 Rhetorical Grammar

Spring: 9 units

The primary objective of this course is to provide professional writers with a framework for identifying and authoritatively discussing the grammatical forms and constructions they will be using. The course also includes some linguistic analysis, a consideration of English orthography, and discussion of the notions of standards and correctness in language. The concern throughout is to develop an understanding of those elements of grammar and usage that are the foundation for good professional writing and for leadership in professional writing settings.

Prerequisite: 76-101

76-390 Style

Fall and Spring: 9 units

In classical rhetoric, "style" is a term that refers not to what we write but how we write. Yet considerations about how we write ? coherence, emphasis, concision, shape, diction, and elegance ? can never be fully separated from an understanding of what, why, and for whom we are writing. Ideally, then, far from being an exercise in expressing personal idiosyncrasies, revising style means understanding a set of strategic choices and always weighing these choices in relation to questions such as, "Who is my audience?" and "What is my purpose"? This course will have two main objectives: (1) to help you develop a repertoire of stylistic options and a critical vocabulary for discussing those options, and (2) to give you the opportunity to put this knowledge into practice when revising writing. Two recurring questions for us will be the following: if style depends on both the rhetorical situation of a text and knowledge of specific guidelines, how can we ever say that we have achieved ?good? style? Should stylistic rules or practical experience carry more weight in the decisions we make as writers?

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>

76-391 Document & Information Design

Fall: 12 units

Today, many professionals are responsible for the visual design of documents. This course provides students who have already learned the foundation of written communication with an opportunity to develop the ability to analyze and create visual-verbal synergy in printed documents. Students will be introduced to the basic concepts and vocabulary, as well as the practical issues of visual communication design through a series of hands-on projects in various rhetorical situations. Assigned readings will complement the projects in exploring document design from historical, theoretical, and technological perspectives. Class discussions and critiquing are an essential part of this course. Adobe Creative Studio (InDesign, Photoshop, Illustrator) will be taught in class, and used to create the assigned projects.

Prerequisites: 76-270 or 76-271

76-393 Corpus Rhetorical Analysis

Intermittent: 9 units

As more of the world's texts become digital and systematically classified, scholars and analysts are increasingly able to analyze not only individual texts but also vast collections of texts, or textual corpora. The analysis of corpora becomes especially important when your focus of analysis is the genus rather than the individual and it has hundreds of applications. It is useful when instead of a single Aesop fable, you want to characterize Aesop's fables as a group and you want to compare them, as a group, with, say, the writings of a contemporary poet or the lyrics of contemporary musical artists. Corpus rhetorical analysis is also useful when you want to compare the styles of two columnists or critics based on a large sample of their writings. It is useful when you want to understand the ?nuts and bolts? rhetorical choices that make software documentation a different professional genre from sports journalism or science writing. This is a hands-on course where students get practice conducting corpus analyses using corpus software and statistical methods. The course is divided into three parts. In the first part, student will learn a theory of textual segmentation that is behind preparing a collection of texts for corpus study. In the second part, students will analyze corpora provided by the instructor and learn how to write a corpus report. In the third part, students will compile a corpus of their own choosing with a research question and then conduct a corpus study and submit a report that seeks to answer that question.

76-394 Research in English

Spring: 9 units

In this course we will explore methods of researching, writing, and presenting original work in English Studies. The field of English Studies is profoundly interdisciplinary. We will strive to understand not just traditionally used methods (such as text analysis), but also more recent developments borrowed from other disciplines (such as history and sociology, anthropology, and visual studies). We will cover methods for developing topics, constructing research plans, finding and using scholarly sources and conducting field research, organizing, writing, revising, and presenting a research paper of 20-25 pages. Students will also learn how to situate their work in the context of scholarly conversation, by testing their hypotheses against alternative and presenting their research to audiences in the field of English studies. Throughout the semester, students will develop and work on an original research project. At the end of the semester, students will give a public presentation of their research to other students and English faculty.

Prerequisite: 76-294

76-395 Science Writing

Spring: 9 units

This course will teach students how to write clear, well-organized, compelling articles about science, technology and health topics for a general audience. Students will learn how to conduct research on scientific topics using primary and secondary sources, how to conduct interviews, and how to organize that information in a logical fashion for presentation. For writing majors, the course will increase their understanding of scientific research and how to describe it accurately and completely to a general audience. For science majors, this course will teach them how to craft fluid, powerful prose so that they can bring their disciplines to life. The course is not intended just for those who want to become science journalists, but for anyone who may have the need to explain technical information to a general audience, whether it is an engineer describing a green building project at a public hearing, a doctor describing the latest research on a disease to a patient advocacy group, or a computer programmer describing new software to his firm's marketing staff. Students will get a chance to read several examples of top-notch science writing and interview researchers, but the primary emphasis will be on writing a series of articles - and rewriting them after they've been edited. The articles will range from profiles of scientists to explanations of how something works to explorations of controversies in science. Students should expect to see their writing critiqued in class from time to time, in a process similar to what journalists routinely go through. The goal will be clarity and verve; the ethos will be mutual learning and enjoyment.

Prerequisites: 76-270 or 76-271 or 76-472 or 76-375 or 76-372

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-396 Non-Profit Advocacy: Genres, Methods, and Issues**

Intermittent: 9 units

Given the changes brought on by the information age, non-profit organizations, like all organizations, face an increasing diversity of audiences and media choices. What hasn't changed is the need for effective arguments (print and digital) that respond to both the rhetorical situations at hand and the ongoing needs of a specific organization. In this course, designed for students pursuing careers in professional communication, we'll examine the critically important practices of argument and advocacy. And while our central focus will be on non-profits, the arts, education, political advocacy and social causes, the techniques we'll learn are also broadly applicable to communications careers in all sectors. Our main focus will be on how professional communicators design arguments and make media choices consistent with the "voice" of their organizations. Among other questions, we will ask, how can we adapt the genres of mass communication to meet our organization's goals? What roles can social media play in non-profit advocacy, and how are those roles changing? How can we have impact while working with limited budgets? The end result will be a professional portfolio that demonstrates both relevant skills and a high-level theoretical understanding of what makes a public argument successful. Students will also gain experience in translating their technical expertise into language that potential employers understand and look for.

Prerequisites: 76-270 or 76-271 or 76-272 or 76-372 or 76-373

76-397 Instructional Text Design

Intermittent: 9 units

This course focuses on the planning, writing, and evaluating of instruction of various kinds, especially instructional texts. It is particularly appropriate for professional and technical writers, but also a good option for anyone interested in fields that involve substantial instruction, such as teaching or employee training. In the first part of the course, we'll examine the recent history of instructional design and the major current theories. Then we'll take a step back and study the concepts of learning upon which these theories are based, with particular attention to their implications for how instruction is structured. You'll find that different learners (e.g., children, older adults) and goals (e.g., learning concepts and principles, learning to apply principles to solve novel problems, learning a procedure, learning to change one's behavior, etc.) require different types of instruction. In the second part of the course, we'll look in detail at models of how people learn from texts and what features (e.g., advanced organizers, examples, metaphors, illustrations, multimedia) enhance learning under what circumstances. We will study and analyze particular types of texts. Some possible examples include an introduction to the concept of gravity; a tutorial for computer software; a self-paced unit in French; adult educational materials in health care; a workshop on sexual harassment in the workplace; or a unit to train someone how to moderate a discussion. We will also look at various methods (concept mapping, think-aloud, comprehension tests, etc.) that are used to plan and evaluate instructional text. You will do a project, either individually or in a small group (2-3), in which you design, write and evaluate instruction.

Prerequisites: 76-271 or 76-270 or 76-272

76-404 New Methods in American Studies

Spring; 9 units

American Studies as a discipline is only about sixty years old — born of Cold War anxiety and expansionism. Think, for a minute, about the fact that the novelist Tom Wolfe (Electric Kool-Aid Acid Test and Bonfire of the Vanities) got his PhD in American Studies at Yale (the first US American Studies program) in 1958. Wolfe says that his grad school exposure to sociology helped him to write about the importance of status for early astronauts in *The Right Stuff*. American Studies is a first cousin to Cultural Studies, but it is not exactly the same thing. In this course we will read mostly secondary texts — scholarly works — that are on the cutting edge of the "new methods" in American Studies, and the course readings will range from the Revolutionary War era to the present. Texts will include Christina Klein, "Why American Studies Needs to Think About Korean Cinema," Jonathan Sterne, MP3, Brian Edwards, ed., *Globalizing American Studies*, Richard Purcell, Race, Ralph Ellison, and *American Cold War Culture*, Walden's Shore: Henry David Thoreau and Nineteenth Century Science, *Wonder of Wonders: A Cultural History of Fiddler on the Roof*, *The Networked Wilderness: Communicating in Early New England*, *Book of Ages: The Life and Opinion of Jane Franklin*, *Gaga Feminism: Sex, Gender and the End of Normal*, *Sense of Place and Sense of Planet: The Environmental Imagination of the Global*, and *Transatlantic Traffic and (Mis)Translations*.

76-412 18th Century Literary and Cultural Studies

Intermittent; 9 units

This class is the first in a two-semester course on what has become, in academic period taxonomies, the long (British) eighteenth century. This period, as constituted in anthologies and course syllabi, extends back to 1660 and pushes well into what has traditionally been called the Romantic period in British literary studies. The rich understanding that the literature and culture of this time period bring to historical narratives of modernity and how we experience them today has motivated scholars to carve out this capacious time frame, and recently, experts in the field have sought to expand its geographic as well as temporal scope by including cultural and textual trafficking between Britain and her North American colonies. Our Fall class will begin with the return of Charles II to the British throne after the turmoil of the English Civil Wars and the Interregnum, and the reopening of the playhouses in 1660. We will end Fall term in the late 1750s with the emergence of the novel as a popular genre in a rapidly expanding print market, and the political and cultural consolidation of a British imperialist presence in North America. In between our beginning and end dates, we will sample multiple genres in print and performance texts as well as visual media and decorative arts produced in and about the British Isles and their North American colonies. Taking both courses is recommended, but not required.

Prerequisite: 76-101

76-413 19th Century British Literary and Cultural Studies

Intermittent; 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Fall 2010: In the early decades of the twentieth century, Irish and British writers transformed literary representation, abandoning the certainty of Realism to delve into representations of the human subconscious resulting in fractured narratives in keeping with the uncertainty of that historically pivotal time. As conceptions of national identity were called into question with traumas associated with the First World War, Modernist writers attended to the tensions between wholeness and disintegration in the individual and in collective bodies. In Irish and British Modernism we will explore the tensions between illusions of a whole associated with political movements like nationalism and fascism and the disorienting though sometimes liberating forces of disintegration that surfaced in the essays, poetry, plays, novels and short stories of four Modernist writers: James Joyce, Virginia Woolf, William Butler Yeats and T.S. Eliot. American Modernism will be offered in the spring, which will build off elements of this initial introduction to Irish and British Modernism. Requirements for this course will include active participation in class conversations, bi-weekly response papers and a fifteen to twenty page research paper.

Prerequisite: 76-101

76-414 Politics, Media, and Romantic Literature 1789-1830

Intermittent; 9 units

The Romantic period in Britain was a volatile era of political and literary revolutions - but also of print-media revolutions that transformed reading, writing, and publishing. This course focuses the question of books, periodicals, and reading audiences through case studies of several Romantic writers: Mary Robinson, William Blake, Samuel Taylor Coleridge, John Keats, William Hazlitt, and William Wordsworth. Reading a selection of their poems, essays, and critical theory in the context of contemporary debates, we will aim to understand the relation between print as a set of material forms, and political as well as literary ideas and discourses that contended for attention in the period's innovative print media. We will also try to grasp some wider cultural processes at work in the late eighteenth and early nineteenth century. These included disintegration of the early modern Republic of Letters and the reconfiguration of its knowledges in the nineteenth-century cultural fields; the forming and division of new reading publics and their ways of reading print; important changes in book production, typography, printing methods (hand-press to steam press), and bookselling; and the crucially important relation between the aesthetic powers of the text and the material pleasures of the "book." Research papers using rare-book materials at the Hunt or Hillman library Special Collections will be especially encouraged; and the course will sometimes meet in the archive to examine "rare and curious" modes of print. One short paper and one research paper will be required.

Prerequisite: 76-101

76-419 Media in a Digital Age

Intermittent; 9 units

How are media in a digital age changing? And how are they changing us? What does it mean to be living in today's communication technology "revolution"? In a time when many forms of communication are digitally based, traveling as bits at e-speeds on global computer networks? To begin answering these questions, we will take as case studies several new discursive digital media formations, such as digital books, on-line newspapers, blogs, wikis, and so forth, along with related social formations, such as social media and distributed non-profit activist organizations. The readings will provide a range of lens by which to understand these developments, including cognitive, social, political, economic and technological aspects. We will briefly put the development of communication technologies in their historical context: How were new forms of communication received in the past? How were they used? How did they affect communication? How did they influence political and social institutions? We will focus, however, on using knowledge of historical developments to inform our understandings of current digital communication developments. Along the way we will ask questions, such as "What are some of the challenges that new digital formations present to traditional communication theories (e.g., What does authorship look like in massively open online collaborations when the boundaries between reading and authoring are blurred? How is trust established when speakers are anonymous and globally distributed? How are identities discursively constructed? How is the "public sphere" constituted when Internet search engines dynamically construct it?)."

Prerequisite: 76-101

76-420 Process of Reading and Writing

Spring; 9 units

This course is an introduction to the thinking, meaning-making process that underlies reading and writing. It asks: what are the social and cognitive processes, what are the conscious and unconscious problem-solving strategies we use: to comprehend and interpret text, to construct and communicate our own meanings, and to project or discover our readers' responses? In the first half of the course we look at writers and designers as thinkers and problem solvers-facing the challenge of equally creative, meaning-making readers and their own constructive, interpretive processes of comprehension. Understanding (and user-testing for) how readers actually interpret texts is critical to many kinds of writing, from informative websites and PR work, to persuasive applications and powerful arguments. An introduction to the research and theory on reading and writing as a social/cognitive process lets us explore the why behind the what readers do. For instance, you will learn how memory networks, cognitive schemas, and meta-knowledge can shape and are shaped by language and discourse as socially constructed mediating tools. At the same time you will develop a portfolio of methods that track the constructive, inferential process of readers' comprehension. In the second half of the course we turn to you and your own writing as a thinking process engaged in the constant effort to juggle competing goals. You will gain insight into your current problem-solving strategies and develop new ones for doing reader-based writing and design. The final project (which studies your own process on a current writing task) will expand your portfolio of methods into a toolkit of expert strategies for 1) both composing and communication and for 2) user testing and inquiry into the comprehension of real readers that uncovers how others actually interpret what you thought you said.

Prerequisite: 76-101

76-422 Theories of Sexuality and Gender

Intermittent: 9 units

Emphasis falls on the "and," the copula between Sexuality and Gender; that is, those theories which either attempt or perhaps are just inevitably drawn into thinking about how the two are related. We will read canonical theories of sexuality—such as Freud's *Three Essays on Sexuality* and Foucault's *Introduction to the History of Sexuality*—and canonical theories of gender—such as Rubin's *Traffic in Women* and Butler's *Gender Trouble*. But we will be particularly attentive to those texts that try to understand connections and disconnections between the construction of the two in theory and in practice. To that end, and to ground our theoretical investigations in social historical context, we will focus on two discursive sites: the feminist "sex wars" of the 1980s and more recent preoccupations of feminists with sexuality, such as work by and on sex-workers, and the theory and practice of "trans"—both gender and sexuality—from the early modern and contemporary periods. Possible readings in the former area might include Pat Califia, Amber Hollibaugh, or Alice Echols; our "trans" cases might include Henry Fielding's *Female Husband*, Foucault's *Herculine Barbin*, Sandy Stone's and Susan Stryker's theoretical work in this area or the biographical writing of "gender warriors" such as Leslie Feinberg.

Prerequisite: 76-101

76-425 Science in the Public Sphere

Intermittent: 9 units

Topics will vary by semester. Spring 2013: Ever since the dawn of the Industrial Revolution and the rise of the technological exhibition in the nineteenth century, there has been a growing presence for science and technology in the lives of everyday citizens. In some cases, these phenomena have sparked the public's imagination and their promise has stirred their confidence in a better future. In other cases, they have kindled fears and generated protests over the risks of new technologies and the threats of novel scientific ideas to prevailing social, cultural, economic, and political orders. This course examines the complex dynamics in the relationships between science, technology, and society. Towards this end it engages with questions such as: How do we decide who an expert is? To what extent do scientists have an obligation to consider the social and ethical consequences of their work? Is public education about science and technology sufficient for addressing social concerns about risk and controversial scientific ideas? We will grapple with these and other questions by exploring modern public debates in which science, technology, and society play a primary role such as the AIDS crisis, global warming, and the autism vaccine debate. With the help of analytical theories from sociology, rhetoric, and public policy, we will develop a general framework for thinking about argument and the dynamics of the relationship between science, technology and the public. In addition, we will look to these fields for tools to assess specific instances of public debate and to complicate and/or affirm the prevailing theories about their relationship. (See Department for full description.)

Prerequisite: 76-101

76-428 Visual Verbal Communication

Fall: 9 units

People create a wide range of communicative artifacts that integrates visual and verbal elements—newsletters, product brochures, web pages, graphical novels, journal articles, resumes, software references, yellow stickies, etc. Yet, such visual-verbal discourse has only recently attracted the serious attention of research communities. Some of the relevant research questions include: Why do visual variations exist across different contexts? (e.g., Popular science looks different from *Discover*.) Why and how do visual styles change over time? (e.g., Magazines from the 1950s don't look like present day magazines.) Do visual elements have persuasive power? If so, what roles do they play in shaping an argument? How do people learn to communicate using visual-verbal artifacts? In this seminar, we will address these and other questions through readings and discussions on various threads of studies around the analysis of communicative artifacts that integrate visual and verbal expressions. We will review key research publications concerning visual-verbal communication from relevant disciplines, including professional & technical communication, rhetoric, argumentation, and literacy. Particular attention will be paid to descriptive methods (e.g., social-semiotic analysis, visual argument, and rhetorical structure theory) and the types of questions these methods can help us answer. Throughout the semester, students will be encouraged to explore the visual-verbal communication artifacts found around them and use those to connect class discussions to the practice of design. Required assignments include a brief bi-weekly response to the readings, several short analysis papers, and a longer term paper with a topic chosen by students based on their professional or research interests. Please see English Dept. for full course description.

Prerequisite: 76-101

76-430 Arthurian Romance and Its Modern Legacy

Fall: 9 units

Arthurian tales have been told and retold in Anglo-American culture for centuries - they have been appropriated for novels (of which medieval romances are the ancestors), poems, operas, films and visual art of many kinds. The Monty Python group assumed that their satire Monty Python and the Holy Grail would be understood in some detail in order for its humor to be appreciated; the nineteenth century poets and novelists had made the same assumption. It is no exaggeration to say that our own structures of feeling concerning love, sex, and adventure still reflect this influence. This course will juxtapose some of the medieval tales that found the genre with their more recent counterparts, for example Chretien's *Lancelot* with Malory's retelling of that story in *Morte D'Arthur*, Tennyson's retelling of Malory, and T. H. White's *Once and Future King* (the basis of the musical and film *Camelot*). Recent novels such as Scott Spencer's *Endless Love*, A.S. Byatt's *Possession*, and Umberto Eco's *Name of the Rose* are also set beside their medieval antecedents. Full participation in all class meetings, brief responses to our texts, and two prepared papers are required for everyone in the course; an additional hour for the discussion of critical and theoretical texts is offered for grad students.

Prerequisite: 76-101

76-431 Chaucer

Intermittent: 9 units

We will read most of Chaucer's *Canterbury Tales* and his narrative poem *Troilus and Criseyde* (considered by some the first English novel). Our texts are in Middle English—Chaucer's language is odd-looking, but easily mastered. We will also read some brief accounts of 14th-century institutions and traditions (chivalry, religious life, marriage, etc.). Most class meetings will consist of discussions that examine these fictions in relation to the social conditions they imply and the tellers' stakes in the telling. While we are discussing the General Prologue, I will ask each of you to identify the pilgrim through whose eyes you will try to read each of the tales (in addition, of course, to seeing from your own vantage point). As the course goes on, you will become an expert on one of the social roles portrayed in Chaucer's fictional universe. Required are near-perfect attendance, steady participation, and three papers. Graduate students will meet for an extra hour a week, read additional materials, and write longer papers.

Prerequisite: 76-101

76-432 Advanced Seminar in African American Studies

Intermittent: 9 units

Topics will vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Fall 2011: This course will be an in-depth study of James Baldwin's works as well as the writers and thinkers that influenced him. Baldwin's rumination on American life during and after the epoch defining events of Civil Rights Era reflects the great political and cultural transformations the country struggled through. In this course students will read canonical works such as *Notes of a Native Son* and *Giovanni's Room* as well as lesser known works like *One Day When I Was Lost*, Baldwin's screenplay for a never-to-be-produced film project on Malcolm X and *Little Man, Little Man: A Story of Childhood*, a children's novel he published in 1976. Besides Baldwin's works we will read and connect Baldwin's thoughts on literature, race, sexuality and politics to some of his immediate contemporaries like Richard Wright, William Faulkner, Flannery O'Connor and others who had an influence on Baldwin's imagination and craft.

Prerequisite: 76-101

76-435 20th Century American Literary and Cultural Studies

Intermittent: 9 units

Topics vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Fall 2010: Before the Beat Generation there was the Lost Generation. Both moments of literary history have an important relevance for our time, and both produced many major literary works. The 20's, like the 50's and 60's were marked by the effects of World War. Gertrude Stein seems to have started the whole generation-naming fad with her comment to Hemingway, "You are all a lost generation." Paul Fussell identifies the cultural effect of WWI as the production of "irony" as the central quality of modern identity. Of course, the "lost" generation wasn't really lost even if it was searching for new ways of understanding experience. And "beat" generation wasn't beaten down either. And irony wasn't invented yesterday even if it still is a dominant mode of modern experience. The last generation to have a really significant name, the beat generation was marked in part by an interest in jazz, and an intense interest in the power of writing. Writing was both a form of recording a response (often oppositional, often ecstatic) to what was going on in the world, and it was also a way of re-inventing the world by discovering some kind of previously hidden secret that only "writing" could uncover. There is a continuing interest in beat writing these days, days which are usually taken to be characterized by a decline in print literacy accompanied by a growth in force of electronic media. So, amongst other things, reading the Beats offers us an opportunity to explore our own times, as well as to read (or-read) a body of powerful visionary literature from the recent past. See English Department for full description.

Prerequisite: 76-101

76-438 Film and Media Studies: Television

Intermittent: 9 units

Topics will vary by semester. Fall 2014: Today television is old media? But what was television like when it was new media?? In this course we will think about how television transformed American culture. We will look at individual genres, like drama, sitcoms, westerns, variety shows and game shows. We will watch I Love Lucy, I Remember Mama, The Goldbergs, The Milton Berle Show, Amos n Andy, Queen for a Day, The Phil Silvers Show, the western Cheyenne, The Honeymooners, Leave it to Beaver and teleplays like Marty and A Man is Ten Feet Tall. We will think about the social and political history of television, including television and the Cold War, television and Civil Rights, and television and electoral politics. Ultimately, the framing question of this class will be a media studies question: how do media technologies change our lives, and how do they NOT change our lives? How is the television revolution similar to our current digital revolution? What can we learn about new media by studying old media?

76-439 Seminar in Film and Media Studies

Fall: 9 units

In the late 1700s moral crusaders were worried about the latest media scandal: the surge in women reading novels. As one observer complained, "Women, of every age, of every condition....retain a taste for novels. I find [novels]...in the work-bag of the seamstress, in the hands of the lady who lounges on the sofa, the mistresses of nobles, the mistresses of snuff-shops, the belles who read them in town, and the chits who spell them in the country." While today we might be genuinely concerned about texting while driving, or the depression associated with high levels of facebook use, in this class we won't judge so much as we will analyze. We will look at what historical media trends have in common with, and how they are different from, the media trends of today. We will read about the print revolution, the electronic media revolution, the current digital revolution, and we will also try to peer into the future. Importantly, we will take a literary and cultural studies approach to this material. We will ask, specifically, what can the humanities teach us about media revolutions over time? How is narrative, or story telling, central to each media revolution? Texts for the class will include: Super Sad True Love Story, Digital Labor: The Internet as Playground and Factory, Spreadable Media: Creating Value and Meaning in a Networked Culture, and Black Code: Inside the Battle For Cyberspace.

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-440 Postcolonial Theory: Diaspora and Transnationalism**

Intermittent: 9 units

Arjun Appadurai argues that one of the primary transformations in this period of globalization has been in the capacity for people to imagine themselves or their children will live and work in places other than where they were born. Although the novel has long been considered a national form, contemporary novels frequently represent transnational mobility, both in their plots and as global commodities. A significant body of contemporary fiction focuses on imaginative and physical movement across national borders. This global literature course combines literary and theoretical readings to examine the experiences of transnationalism and diaspora. Theories of transnationalism look at the interconnections that cut across nations. The concept of diaspora, a term first used to reference the movement of a people out of a homeland, has become a way to think about the identities of immigrants, migrant workers, and refugees. Readings for the course will be drawn from a diverse group of writers from around the globe. Literary readings might include works by Caryl Phillips, Jamaica Kincaid, Christina Garcia, Nadeem Aslam and Jhumpa Lahiri; theoretical readings might include works by Salman Rushdie, Paul Gilroy, Gloria Anzaldúa, Arjun Appadurai, Inderpal Grewal and Avtar Brah.

76-443 Shakespeare and Theory

Intermittent: 9 units

Shakespeare's plays have been produced and read under all sorts of conditions for more than 400 years. It seems that each generation has a different take on their meanings and implications. Early criticism weighed their "beauties" and "flaws," and more recently their place in intellectual and social life has been analyzed by deconstructive, historical, psychoanalytic, marxist, and feminist commentary. In the seminar, we will read six plays (one comedy, one history, one "problem play," one romance, and two tragedies) each accompanied by an essay proposing a particular theoretical position and some related criticism. Students will be honing their skills as readers of some of the most complex and challenging texts in the English language and simultaneously learning to write criticism of their own. This seminar is not an introduction to Shakespeare; it is designed for students who have thought seriously about some of the plays (studied at the college level, acted in or directed productions, or the like) and wish to broaden and deepen their understanding. It is not limited to English and Drama majors. Regular attendance and participation (including occasional in-class writing) are required. Everyone will present a "position statement" to the seminar and submit two prepared papers. Grads and undergrads will work together every week for three hours; grad students will meet for an extra hour each week to discuss additional readings and prepare conference-ready seminar papers.

Prerequisite: 76-101

76-444 Studies in Print Culture: History of Books and Reading: Media before "New Media"

Intermittent: 9 units

Rather than putting an end to the book (as McLuhan had forecast) digital media have had the oddly exhilarating effect of making us look at all kinds of print, past and present, through newly focused lenses. This course will introduce you to the history of books and reading, a cross-fertilizing field of study that is having an impact on many disciplines, from the history of science to literary history, cultural studies, and the arts. We will read scholarship in this still-emerging field to orient you to its key issues, practical and methodological problems, and theoretical implications: work by Roger Chartier, Michel Foucault, Elizabeth Eisenstein, Pierre Bourdieu, Michel de Certeau, Adrian Johns, and others. We'll also read primary texts of the eighteenth and nineteenth centuries?including Joseph Addison, Jane Austen, Samuel Coleridge, Charles Dickens and Wilkie Collins—to see how differing modes of print and reading were keenly contested cultural and political matters in the eighteenth and nineteenth centuries. Other topics include the division between new reading publics and their ways of reading books; important changes in book production, typography, printing methods (hand-press to steam press). We will study the relation between the aesthetic powers of the text? and the material pleasures of the book?; the emergence of a modern, imaginative category of literature? in conjunction with the consolidating power of the novel. Such knowledge of the history of print has become especially crucial in an era of emerging new media? and the field of digital humanities in the university. Two papers will be required?one shorter paper (5-7 pp.) and a longer research paper on the uses of books and print by producers and readers. Though the course meets in Baker Hall, you will have hands-on experience with early books and other forms of print as we also meet periodically in the Rare Book Room at Hunt Library.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>

76-445 John Milton: Poetry, Paradise, and Revolution

Intermittent: 9 units

Although censored and reviled by many in his own day, John Milton (1608-1674), author of *Paradise Lost* among other powerful anti-monarchical writings of the English Revolution, has influenced writers as varied as William Blake, Mary Shelley, Thomas Jefferson, Friedrich Engels, C.S. Lewis, Malcolm X, and Philip Pullman. This course will investigate what has made Milton a writer at once so much imitated and beloved by his admirers and loathed and denigrated by detractors. The bulk of this course will center on a careful, challenging, and chronological reading of Milton's works, primarily *Paradise Lost* but also his great shorter poems including *Lycidas*, *Paradise Regain'd*, and *Samson Agonistes*, and selections of his voluminous prose (*Areopagitica*, *The Doctrine and Discipline of Divorce*, *Tenure of Kings and Magistrates*, *Readie and Easy Way to Establish a Free Commonwealth*). Studying Milton's development as a poet, controversialist, and pamphleteer, students will examine Milton's contexts (chiefly, literary, political, and theological) in order gain further insights into the complex relations between Milton's 17th century world and his major poems and prose. Milton's works will be read in dialogue with works by other major 17th century poets and controversialists such as Thomas Hobbes, Andrew Marvell, John Dryden, and Lucy Hutchinson. Finally, we will explore Milton's subtle and not-so subtle influence on later writers in contexts ranging from the Enlightenment, to the Romantic period, to the American Revolution, to the Cold War.

76-446 Allegory

Intermittent: 9 units

Topics vary by semester. Fall 2012: Allegory has both a broad meaning involving any attachment of ideas to literary structure and a narrow meaning in which simple morality tales feature characters like *Fellowship and Good Deeds*. We will make use of both broad and narrow definitions. The long reign of "realistic" fiction was levered against allegory, which was often dismissed of as simpleminded, unattractively didactic, and "medieval." More recently, sometimes in connection with our current interest in "alternative universes," the term and the concept have taken on a new importance in political discourse and in the interpretation of science fiction. The course will consider some medieval, some twentieth century, and some very recent allegories (mostly on film or video), in an attempt to explore theories of both allegorical and realistic narrative modes. Prerequisite: 76-101

76-448 The Global Renaissance

Intermittent: 9 units

We are living in a "global" age. So, at least, we are often told. But it was in 1571, after all, that silver extracted in South America was first traded in China, for porcelain. So when did we become "global?" What were we before we were "global?" Or has humanity always already been "global?" In any case, why do so many people insist on speaking of "globalization," as though "global" was a destination we haven't yet reached? This course anchors such questions in the literature, history, and culture of the English Renaissance, a period regularly invoked as "foreshadowing" or "inaugurating" current-day globalization. With attention to major figures like Shakespeare and Donne, but also to lesser known merchants, travelers, cartographers, imperialists, linguists, and lawyers, we will investigate the argument that the roots of our present "global" age can be identified in the sixteenth and seventeenth centuries. In order to develop more sophisticated thinking about history's relation to our own putatively unique, "global" age, students will read primary works alongside a healthy helping of historical scholarship and theory. Assignments will include a review presentation, an annotated bibliography, and an article-length final research paper. Prerequisite: 76-101

76-449 20th Century American Literary and Cultural Studies: College Fiction and Film

Intermittent: 9 units

Topics will vary by semester. Consult the course descriptions provided by the department for current offerings. Example, Spring 2010: College seems a space apart, before you enter the real world. Accordingly, we don't think of fiction and film that depicts life in college as all that serious. However, there is a growing tradition of fiction of university life, whether of students or professors. In particular, a great many prominent contemporary writers have written novels set on campuses, and a number of major film directors have turned their lights on university life. In this course, we will survey the realm of college fiction and film, from F. Scott Fitzgerald to Michael Chabon. We will try to put together its history, distinguish its major types, and diagnose its contemporary representations. We will also look at relevant historical, theoretical, and sociological works that bear on the university. There will be several short papers and one longer final paper. Prerequisite: 76-101

76-450 Literary and Cultural Theory: Law, Culture, and the Humanities

Intermittent: 9 units

"I'm not a lawyer, but..." How many times have you heard this disclaimer, closely followed by a lay analysis of law? This course, an introduction to the cultural study of law for graduate students and advanced undergraduate students, can be seen as an introduction to what goes into the making of such a statement. Where do we get our ideas about law? What do we mean when we say "law"? What counts as law? How does culture influence law, and law, culture? And to what degree should historical context condition any answers we might be tempted to give? Students in the course will study works in a range of genres (novels, plays, poems, judicial opinions, pamphlets) and develop methods for investigating ways that law and culture have been made by one another from the 16th-century to the present. Readings will include influential theoretical accounts of law (Aristotle, Hobbes, Cover, Habermas, Bordieu, MacKinnon), canonical texts in Law and Literature (Shakespeare's *Measure for Measure*, Melville's *Billy Budd*, Kafka's *The Trial*) and some "weird fiction" by the novelist/legal theorist China Miéville. As a counterpoint to the fiercely a historical "law and economics" movement, however, the course will put special emphasis on rooting intersections of law and culture in rich historical context, considering both local and international legal contexts (sometimes in fairly technical detail) alongside so-called "ephemera" of culture. Students will tackle the especially fruitful "case" of Renaissance Britain before developing final research projects, whether on the Renaissance or another period of their choosing. Prerequisite: 76-101

76-451 Topics in Language Study

Intermittent: 9 units

Seminars focusing on topics in linguistics and discourse studies. Topics will vary by semester. Consult detailed course descriptions available from the Department each semester for details. May be repeated for credit. Fall 2011: The linguistic and social history of the English language from its earliest attestations until the global spread of English and the emergence of the spectrum of "Englishes" in the modern world. We will single out some of the critical periods of change and study them for their linguistic and sociocultural significance. The periods studied will include: the Germanic background; Old English; English from the Norman Conquest (1066) until the introduction of printing (1476); Early Modern English; Present Day English. We will study short texts characteristic of their time and examine linguistic and sociocultural features diagnostic of their age, social class, and region. Prerequisite: 76-101

76-452 Patterns of English Usage

Intermittent: 9 units

Patterns of English Usage is for both graduate and undergraduate students a research course. This means that for all students there is an emphasis on carrying out investigations at first hand and reporting your results. The course is intended to provide experience in recovering data on patterns of English usage from a corpus. It is an introduction to "corpus linguistics," a set of techniques for studying the distribution of words and phrases as they are actually used in discourse (as opposed to how we might think or imagine they are used without reference to texts). Corpus linguistics is a new field. It incorporates methods and concepts that have only become possible since the advent of large-scale data storage and high-speed search software. It challenges normative grammar by asking whether we are entitled to say that words and phrases have dictionary meanings that are distinct from their uses in discourse. It takes grammar away from authorities and places it in the mouths and pens of users of the language. We will be using the Cobuild (Collins/Birmingham University International Linguistic Database) corpus. By the end of the semester you will have learned the conventions for entering a well-formed Cobuild query, including various wildcard and category-dependent searches, and some elementary corpus concepts such as "collocation" and "transitional probability." You will also have learned about some aspects of conventional approaches to English grammar (structural grammar, generative grammar) with which to compare and contrast the corpus approach.

76-453 Literature of Empire

Fall: 9 units

Critic David Attwell once characterized a novel about empire as focused on "that moment of suspension when an empire imagines itself besieged and plots a final reckoning with its enemies." The same might be said of late-nineteenth and early twentieth-century British literature, which was shaped by events taking place outside as well as inside of national borders. Even in the eighteenth and nineteenth centuries, with international trade and slavery supporting the manor house and plantations abroad providing the cotton for British looms, the "England" of English literature spanned the globe. By the first half of the twentieth century, this empire had begun to collapse in upon itself, a process witnessed by writers inside Britain and its colonies. This course will investigate British literature within the international context of global imperialism. A section on gothic stories takes us into the realm of popular culture with H. Rider Haggard's *She*. We trace the torturous path into *Self and Other* in Joseph Conrad's *Heart of Darkness*, consider the portrayal of the Creole in Jean Rhys' *Wide Sargasso Sea*, and outline the links between colonial empire and international war rendered in Virginia Woolf's *Mrs. Dalloway*. These literary works will be read alongside some of the most important works of postcolonial theory, including articles by Edward Said, Chinua Achebe, Anne McClintock, and Gillian Beer.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-457 Topics in Rhetoric**

Fall: 9 units

In this unsettled age, when large portions of the earth's surface are being ravaged by industrialism, when on several continents indigenous peoples are being forcibly uprooted, when philosophers and poets (and even the odd sociologist or two) are asserting that attachments to geographical localities contribute fundamentally to the formation of personal and social identities, when new forms of 'environmental awareness' are being more radically charted and urgently advocated than ever in the past? it is unfortunate that [we] seldom study what people make of places. (Keith H. Basso, "Wisdom Sits in Places") It is sometimes claimed that place is no longer important in human life, now that we spend more and more time in virtual spaces and participate more and more in global economic and social networks. In this course we will test this claim, first by reading and discussing theories of place and space from critical theory and cultural geography, and then by reading about and carrying out case studies exploring intersections between discourse (talk and writing) and place. Our methods will include bibliographic and archival research, discourse analysis, and ethnographic techniques. Students' projects will draw on your professional and scholarly interests and expertise, and the places and discourse practices you study can range from the local (a workplace, for example) to the global (the internet, for example). My project, and our first case study, explores the changing (but persistent) roles of regional US dialects in the formation and use of identities.

Prerequisite: 76-101

76-460 Beginning Fiction Workshop

Fall and Spring: 9 units

This course builds upon survey or introduction courses to exercise the writer's craft in fiction. Several texts will be analyzed, in both the short story and novel forms. We will read closely with a focus on the craft of writing? the voice, point of view, character development, etc. We will develop a vocabulary for speaking about the craft of fiction and hone our skills by reading good fiction, discussing work in class and writing response papers with an eye toward the various aspects of the writing process. We will arrange a schedule in which each student's work will be reviewed twice via peer review and in-class discussion.

Prerequisite: 76-260

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-462 Advanced Fiction Workshop**

Fall and Spring: 9 units

In this class we will work on how narratives are told. Using masterworks to help guide our writing, we will spend the first part of the semester writing stories that imitate the style or narrative voice of several authors. You will have a story due every week. We will workshop several of these stories concentrating our editorial comments on story, development, character, and voice. Your time after mid-semester will be devoted to rewriting and reworking these exercises into stories.

Prerequisite: 76-460

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-464 Creative Nonfiction Workshop**

Intermittent: 9 units

Many writers mine a theme or subject throughout the course of their careers? this includes journalists who write exclusively about such things as music, sports, politics, culture, and fashion, as well as writers whose focus is on parenthood, ethics, health or psychology. At the start of this workshop, writers will choose a particular area of interest and spend the entire semester writing about their subject from different perspectives and for different audiences and publications. Forms we will cover will include the essay, the magazine feature, the profile, the one-pager, memoir, and the on-line piece. Students will be expected to become familiar with different potential markets for their work. Assignments will include a portfolio at semester's end with six pieces, including at least two that are polished and ready for submission to an appropriate publication.

Prerequisites: 76-260 or 76-262 or 76-265 or 76-365 or 76-460

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-465 Advanced Poetry Workshop**

Fall and Spring: 9 units

Fall 2015: The Poet in America. This course will combine reading and discussion of work written by significant poets in America's past. Beginning with the first poet in America, Anne Bradstreet, we will attend to the poems of a number of major figures through a consideration of Berryman's "Homage to Mistress Bradstreet." In alternate sessions we will be thoroughly involved with reading and discussions of poems created by members of the class. Spring 2015: This course will combine three elements: the reading and discussion of a number of books of contemporary poetry in conjunction with visits by the poets, the writing and workshopping of original poems by class members, and a collaborative mentoring project with the literary arts students at the Pittsburgh High School for the Creative and Performing Arts.

Prerequisite: 76-365

76-469 Advanced Screenwriting Workshop

Intermittent: 9 units

This team-taught course is designed for students interested in writing for one-hour dramatic television and those who are interested in image-driven screenwriting. Students will choose one form or the other by end of the first week. Both television and film writing employ many of the same techniques and present many of the same problems. By teaching both forms together we believe writers will gain from each perspective. Assignments for TV writers include analysis of the chosen show, creation of show breakdowns, scene studies, and beat sheets. Screenwriters will work on creating a usable premise, dimensional characters, a detailed act structure, and a step outline. Lectures include fundamentals of dramatic structure, dialogue, and script format. Both groups will produce an interim and final draft; both will have their work critiqued in class. The final project for students who choose TV writing is a "spec script" for a one-hour drama, broadcast in the US any time during the last 30 years. Image-driven screenwriters will produce by semester's end an original 60-minute screenplay.

Prerequisite: 76-269

76-472 Topics in Journalism: Multimedia Storytelling in a Digital Age

Spring: 9 units

This course explores the craft of journalism in the context of the history, traditions and glory of journalistic nonfiction in the United States. It seeks to help you hone your writing and thinking skills as you produce pieces of substance that reflect those traditions and standards. As a published author, foreign correspondent and Pulitzer-Prize winning editor, the instructor has been a foot soldier in print journalism and media management for 30 years. The practical emphasis of the course reflects his extensive and varied background. The course focuses on the four stages necessary to any nonfiction story: idea, concept, reporting and writing. Subjects include how to make news judgments, gather evidence, make word choices, compose stories and interpret events, unpacking the language and vocabulary of the craft of journalism. As part of our exploration of advanced nonfiction styles, we examine the six major genres of journalistic nonfiction: the trend story, the profile, the explanatory, the narrative, the point-of-view and the investigative. We will read, critique, discuss and analyze examples of each genre, and students will produce work of their own in four of the genres. Students may substitute (for one of the four writing genres) independent research on a topic of their choosing. In addition, we explore journalism's glorious past and its role in the promotion and maintenance of democracy. The last segment of the course examines the evolution of journalism in the digital age and the impact that is having on the media landscape, particularly print. Students will be given assistance and encouragement as they seek outlets for their writings and connections in the media world that could lead to internships and employment.

Prerequisite: 76-101

76-474 Software Documentation

Spring: 9 units

This course teaches best practices for creating software documentation (user assistance) for internal and external users. We will analyze many forms of software user assistance and discuss their roles in the progressive disclosure model: Provide the right information to the right user at the right time. The course emphasizes quality task-oriented writing and focuses on the basic skills needed to educate and guide users, while introducing important industry trends like topic-based authoring, single sourcing and reuse, and DITA. Students will complete a series of short homework assignments and several larger projects to reinforce the principles and provide experience in all phases of creating software documentation, including peer review. Readings and published documentation examples will provide a bridge between theory and practice. No textbook required, but students may be required to purchase necessary software (a DITA editor). Prerequisites: 76-270 or 76-271

76-475 Legal Rhetoric in a Global World

Intermittent: 9 units

Although rhetoric and law have long been closely associated, the modern professionalization of law has often promoted the idea that legal discourse is not rhetorical at all but instead an objective, value-neutral science that can be applied independent of social or political influence. This view of legal discourse is disputed by critics who point out the figurative aspects of legal language, the importance of character, emotion, and narrative in legal discourse, and the ways in which law protects structures of power such as race, class, and gender privilege. In this course we will examine the often fraught relationship between rhetoric and law by considering the ways in which legal discourse is directed to global audiences, particularly the ways in which legal systems are portrayed to reflect ideals of democracy to suit particular geopolitical goals. We will begin by studying the ways in which desegregation and civil rights discourse in the United States was influenced by cold war politics, then we will study the ways in which the prosecutions of deposed rulers in emerging democracies have been orchestrated to persuade global audiences that the society observes the "rule of law." Alongside primary sources of legal rhetoric, we will study a selection of interdisciplinary scholarship about the relationship of rhetoric and law. Students will write a 15-20 page research paper that situates a legal case of global significance within a scholarly conversation about rhetorical theory. The paper will emerge from a series of short writing assignments totaling 70% of the grade, and the remaining 30% of the grade will consist of additional short writing assignments, reading responses, a presentation, and class participation.

76-476 Rhetoric of Science

Intermittent: 9 units

Rhetoricians study how strategic use of language and argument contribute to the development of scientific knowledge and how science is communicated and argued within the technical and the public spheres. In this course, we will examine various aspects of scientific communication including scientific audiences, visuals, and conventions for argument. In particular, we will explore the questions: What happens to scientific information and argument when they move from specialist journals into the mainstream media? In what ways might emotion and the character of the scientist influence scientific debates? What role do metaphor, analogy, and other stylistic features play in developing scientific thought and argument? And what role do visuals play in arguing science? To investigate these questions, we will be examining a broad range of real-world discourse from scientific journals to mainstream media and engaging with a broad range of scholarship in rhetoric, sociology, anthropology and philosophy of science. Whether you have a background in science or not, this course is designed for anyone interested in learning more about the practices and challenges of scientific communication and argument. Prerequisite: 76-101

76-479 Public Relations & Marketing for Writers

Spring: 9 units

Effective marketing and communications are essential to the success of businesses, non-profit agencies, academic institutions, public interest groups, and other entities that have a shared purpose and identity to promote. This course explores marketing and communications in organizational settings, where professional communicators manage relationships with a wide variety of constituencies: customers, investors, news agencies, employees, members, volunteers, local communities or government agencies. To succeed, communicators must be able to identify and articulate the communication needs of the organizations they represent, develop well-informed strategies for advancing organizational objectives, think and act quickly in high-pressure situations, and write clear and persuasive prose. In this course, you will develop the written and oral communication skills needed by a professional communicator in an organization. You will learn to identify and define a coherent, integrated strategy for all of an organization's communications and to devise and apply effective marketing and public relations tactics in traditional and social media for achieving business objectives. You will gain practice in writing op-ed essays, press releases, critiques of organizational communications, and marketing and communication plans. Prerequisites: 76-271 or 76-270

76-481 Writing for Multimedia

Fall: 12 units

There is increasing demand for professional/technical writers who understand multimedia and its communicative possibilities. This class will provide students with the opportunity to develop the ability to analyze and create multimedia experiences. Students will be introduced to the basic concepts and vocabulary of multimedia, as well as the practical issues surrounding multimedia design through a series of hands-on projects involving various contexts. We will explore what it means to write for a dynamic medium and how the elements of time, motion and interactivity can help writers expand their communicative skills. Class discussion and critiques are an essential part of this course. While students are not expected to become masters of multimedia software, Adobe After Effects, Adobe Flash, audio and additional creative tools will be taught in the class in order to provide them with the basic skills necessary to complete assignments and explore multimedia possibilities. Prerequisites: (76-270 or 76-271) and (51-261 or 51-262 or 76-391)

76-482 Comparative Rhetoric

Intermittent: 9 units

This course serves a two-fold purpose. It attempts (1) to address the theoretical and methodological issues in cross-/inter-cultural communication from a rhetorical point of view and (2) to examine critically the way comparative studies of different rhetorical traditions/systems are currently conducted. In particular, it is concerned with the rhetorical problems we encounter in trying to write, argue, and persuade across languages and cultures. And it aims to take a close look at the need for rhetoric to rethink its own identity, purpose, formation and agenda in an increasingly multicultural and globalized world.

76-483 Corpus Analysis in Rhetoric

9 units

This course investigates methods for analyzing rhetoric as it mainly exists in digital environments (e.g. blogs, newsgroups, homepages, political sites, facebook and so on). The focus will be on verbal rhetoric, but students who wish to analyze visual rhetoric interactively with verbal rhetoric will be welcome to do so. In the first part of the course, we will review various methods for analyzing digital texts descriptively (viz., concordance, collocate and keyword analysis) and inferentially, through multivariate analysis (e.g., manova, factor analysis, discriminant analysis, cluster analysis). To learn these methods, in the first half of the course, we will use simple textual data sets supplied by the instructor. In the second half of the class, students will choose their own digital environments to analyze and they will be expected to write publishable-quality rhetorical analyses of these environments. To meet this expectation, students will need to do considerable background research in the digital environments they are studying.

Prerequisite: 76-101

76-484 Discourse Analysis

Fall: 9 units

Discourse is a focus of study in most of the humanities and social sciences, and discourse analysis is practiced in one way or another by anthropologists, communications scholars, linguists, literary critics, and sociologists, as well as rhetoricians. Discourse analysts set out to answer a variety of questions about language, about writers and speakers, and about sociocultural processes that surround and give rise to discourse, but all approach their tasks by paying close and systematic attention to particular texts and their contexts. We are all familiar with the informal discourse analysis involved in paraphrasing the meanings of written texts and conversations, a skill we learn in writing and literature classes and in daily life. Here we ask and answer other questions about why people use language as they do, learning to move from a stretch of speech or writing or signing outward to the linguistic, cognitive, historical, social, psychological, and rhetorical reasons for its form and its function. As we look at resources for text-building we read analyses by others and practice analyses of our own, using as data texts suggested by the class as well the instructor. In the process, we discuss methodological issues involved in collecting texts and systematically describing their contexts (ethnographic participant-observation and other forms of naturalistic inquiry; transcription and "entextualization;" legal and ethical issues connected with collecting and using other people's voices) as well as methodological issues that arise in the process of interpreting texts (analytical heuristics; reflexivity; standards of evidence). The major text will be Johnstone, Barbara. 2008. *An Introduction to Discourse Analysis*. 2nd ed. (Malden, MA: Blackwell Publishers). Other reading will be made available as .pdf files.

Prerequisite: 76-101

76-486 Argument Theory

Intermittent: 9 units

"The difficult part in an argument is not to defend one's opinion, but rather to know it." -André Maurois This seminar will be an in-depth exploration of theories of argument and assumes some prior knowledge or coursework in argumentation such as acquired in 76-373-773. As the above quote from Maurois suggests, we will take a broad view of the concept of ? argument? and examine its role as a discursive means of truth seeking, knowledge creation, and decision-making, not just as the practice of using language to justify or refute a conclusion. The goal of the seminar is for participants to acquire the concepts needed to read the current research/scholarship on argumentation with understanding, to apply that research to the analysis of arguments, and to be positioned to contribute to that research. We will begin with a brief history of the classical Greek writings on logic, rhetoric and dialectic, especially the writings of Aristotle. There are questions from that tradition that endure to this day: What does it take for a conclusion to be well supported? What criteria should govern acceptance of a conclusion? We will also examine two landmarks in the contemporary study of argumentation, Perelman and Olbrechts-Tyteca's *The New Rhetoric* and Toulmin's *The Uses of Arguments*, both published in 1958.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-487 Web Design**

Fall: 12 units

As the Internet has increasingly become an integral part of professional and technical communication in all organizations, writers entering the workplace are expected to have a broad range of web design skills to complement their expertise in writing and design for print. Thus, we've designed this course to help writers learn the broad range of skills needed to develop communication materials that are tailored for the web. In particular, the course focuses on the planning, design, and testing of the visual and verbal content typical of contemporary websites. As a member of the class, you'll participate in a guided, semester-long web design project, which is scaffolded with a series of group and individual assignments. The project begins with an introduction to user-centered methods for understanding the audience (users), where you will learn and practice foundational user-centered design methods through readings and a series of hands on exercises, including interviews, and observation of actual users. You will also learn theories and methods for developing effective information architecture, including organizational schemes, navigational design, labeling, form design, and visual design. Working in groups with other students, you will, over the course of the semester, develop a prototype of a small website, which will be evaluated through user testing at the end of the semester. While we focus primarily on the activities described above, we'll also discuss sound and animation, emerging technologies such as Web 2.0 and Mobile Web, and social media.

Prerequisites: (76-271 or 76-270 or 76-272) and (51-261 or 51-262 or 76-382 or 76-391)

Corequisite: 76-488

76-488 Web Design Lab

Fall: 3 units

Lab exercises for Web Design include the following: basic HTML, images, tables, animation, image maps, interactive forms, Web interfaces to databases, and basic Javascripting. All students must do the lab exercises. The exercises are designed so that those students who already know particular topics (e.g., basic HTML) do not need to attend the lab session. Students who would like guided practice in doing the lab exercises must attend the lab session. Lab sessions take place in a computer cluster.

Prerequisites: (76-270 or 76-271 or 76-379) and (76-382 or 76-391 or 76-383)

76-491 Rhetorical Analysis

Intermittent: 9 units

Students in this course will learn various approaches to analyzing discourse artifacts from a rhetorical point of view. Early in the course, students will identify an artifact or artifacts they wish to analyze. From there, students will be encouraged to explore their own methods of analysis based on two required books for the course and reviews of literature. For the midterm, students will create an annotated bibliography of five specimens of criticism taken from a single journal. For the final project student will first present and then hand in a polished 15 page piece of criticism based on one or some combination of methods. The presentation and final paper count 50% of the grade, with the mid-term, class attendance, participation, and homework making up the final 25%.

Prerequisite: 76-101

76-492 Rhetoric of Public Policy

Intermittent: 9 units

The field of public policy focuses on the study of how to avoid or resolve social problems and achieve social goals through political processes. In traditional approaches to public policy, each step of the policy process from defining a problem to making a case for its solution is assessed in reference to rational models of economic and political actors. This course takes a less conventional rhetorical approach to public policy which focuses attention on the values, beliefs, and argument structures associated with issues as a method of assessing them and as a means for moving forward with effective strategy for their resolution. Towards this end, we will be studying the theories and analytic methods of both classical and modern rhetorical scholarship as well as modern public policy theory.

Prerequisite: 76-101

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>**76-494 Healthcare Communications**

Fall: 9 units

Healthcare Communications is a writing-intensive course designed for students interested in how healthcare information is developed by researchers, healthcare providers and writers and communicated to patients and their families, the general public, and other experts. Throughout the course, we will explore where people find medical information, how they use and evaluate it, and what challenges writers face in supporting informed healthcare decisions while communicating ideas that can be complex, provocative and sometimes frightening. We will read and discuss published literature dealing with issues in health literacy, clinical research, and patient care. We will also learn the basics of reading, understanding, and interpreting the research literature and communicating research findings to non-experts. Early in the semester, you'll choose a medical area of interest that you will research using sources such as journals, articles, books and web sites, as well as direct contact with appropriate medical, healthcare, and/or research professionals. For your final project, you will write and design materials that will meet a specific need or gap you identify in existing information. The final project could be a magazine article, a website, patient education material such as brochures or training materials, or another vehicle that emphasizes accurate, informative and engaging writing. In addition, there will be several short writing assignments to build the research and writing skills needed to effectively communicate healthcare information. A background in health, medicine or science is not necessary for this course, but a willingness to learn about these areas is essential.

Prerequisites: 76-270 or 76-272 or 76-271 or 76-395

76-497 Culture: Interdisciplinary Approaches

Fall: 9 units

to be determined

76-511 Senior Project

Intermittent: 9 units

Seniors in all four majors within the English Department may, with faculty permission and sponsorship, design and complete an original, student-planned Senior Project. Creative Writing majors may work on a book-length manuscript in fiction or poetry. Students in all majors within the Department may also, with the permission of a faculty advisor who will supervise and sponsor the project, develop and complete senior projects that involve either traditional academic research or investigations of problems in professional or technical communication.

76-758 Rhetoric and Narrative

Spring: 12 units

Narratives are most frequently thought of as a literary genre but in reality they are a much more diverse and highly rhetorical genre. Narratives are also a powerful way of influencing the interpretation of events and situations, and the promotion of certain goals and agendas. They are in fact a form of strategic discourse. We see this, for example, in the increasing use of narrative in journalism, in the presentation of controversial historical events, in current political debates about immigration reform, and in workplace communication. In these contexts, narratives function as a source of authority and legitimation. To understand this function, we will discuss several key concepts in narrative theory, and then apply them to several case studies. We will look at how immigrant narratives circulating in the United States create stock images of immigrants as a threat; at how politicians use autobiographical narration to claim authority; and at how workplace narratives establish roles, boundaries, and power relations. The requirements for this course include one mid-semester take home exam (made of short essay questions and the analysis of a given text) and a final research paper.

76-786 Language and Culture

Fall

This course is an introduction into the scholarship surrounding the nature of language and the question of how language shapes and is shaped by social, cultural and political contexts. We will begin by studying important literature in linguistics and language theory, both to introduce us to how scholars think about language and to give us a shared vocabulary to use for the rest of the semester. We will then move into case studies and theoretical works exploring the intersections of language use, individual and group identities, and the exercise of power, in its many forms. In particular, we will focus on the relationship between language and culture by asking, in what ways does language influence and constitute social change? How is social change reflected by changes in the way we use language? Over the course of the semester, you will work on applying the knowledge and theoretical tools you gain to your own analysis of a linguistic artifact that you choose.

Course Website: <http://www.cmu.edu/hss/english/courses/index.html>

76-852 Readings in Marxism

Fall: 12 units

This seminar will focus on problems in Marxist theory, among them value and labor, mode of production, base and superstructure, and historical materialism. However, because of our particular disciplinary interests, the course will focus on problems of ideology, including hegemony, culture, and the subject. Readings begin with works of Marx and Engels, including selections from *The Economic and Philosophic Manuscripts*, *Capital*, Vol. 1, and *The German Ideology*, and move on to other contributors including Lukács, Gramsci, Althusser, and Zizek. We may take up the Frankfurt school briefly. We will look at Raymond Williams, David Harvey, and Fredric Jameson as examples of Marxism in the specific context of cultural studies. The course will end with some investigation of various sorts of "post-Marxism," for example, Laclau and Mouffe, and Agamben.

76-854 Foundations of Cultural Studies

Fall: 12 units

This course is the first part of a year-long seminar where students will study some of the more canonical and perhaps not so canonical work of American literary and cultural criticism. The aim of this seminar is to generate a comprehensive knowledge of key works, delineate trajectories, acknowledge blind-spots, and critically scrutinize the key figures and intellectual history of American literary and cultural criticism. The primary works in this class will be big and rather challenging works of literary criticism and theory accompanied by a smattering of novels and poems. The first part of this course will focus on the critics, poets, novelists and interpretive trends that defined American literary and cultural criticism up until World War II. Some of the authors we will read include: Williams Dean Howells, Van Wyck Brooks, Mark Twain, W.E.B. DuBois, Alain Locke, William Carlos Williams, John Crowe Ransom, Robert Penn Warren, Alfred Kazin and F.O. Matthiessen.

76-881 Writing for the Multimedia

Fall

There is increasing demand for professional/technical writers who understand multimedia and its communicative possibilities. This class will provide students with the opportunity to develop the ability to analyze and create multimedia experiences. Students will be introduced to the basic concepts and vocabulary of multimedia, as well as the practical issues surrounding multimedia design through a series of hands-on projects involving various contexts. We will explore what it means to write for a dynamic medium and how the elements of time, motion and interactivity can help writers expand their communicative skills. Class discussion and critiques are an essential part of this course. While students are not expected to become masters of multimedia software, Adobe After Effects, Adobe Flash, audio and additional creative tools will be taught in the class in order to provide them with the basic skills necessary to complete assignments and explore multimedia possibilities.

Prerequisite: 76-791

76-891 Rhetorical Analysis

Fall and Spring

Students in this course will learn various approaches to analyzing discourse artifacts from a rhetorical point of view. Early in the course, students will identify an artifact or artifacts they wish to analyze. From there, students will be encouraged to explore their own methods of analysis based on two required books for the course and reviews of literature. For the midterm, students will create an annotated bibliography of five specimens of criticism taken from a single journal. For the final project student will first present and then hand in a polished 15 page piece of criticism based on one or some combination of methods. The presentation and final paper count 50% of the grade, with the mid-term, class attendance, participation, and homework making up the final 25%.

Entertainment Technology Pittsburgh Courses

53-230 Programming for Game Designers

Spring: 12 units

Game design sits at the crossroads of many different disciplines—programming, art, writing, design, engineering, psychology, and more. This course takes a practical approach to programming and how it can be used to make one a better game designer. Through individual & collaborative projects, students will learn programming tools, techniques for working with data, methods of working with teams, and prototyping strategies. This course is geared toward non-programmers looking to add programming to their game design toolset.

Prerequisites: 15-104 or 62-150

53-312 Guest Experience and Theme Park Design

Fall: 12 units

Students will research the history of the Themed Entertainment Industry and study key phases including conceptualization, design, building, management and delivery involved in creating the total themed entertainment experience. The class will focus on the importance of creating the total guest experience. Discussions on story and storytelling will address the different aspects of both franchise and original stories. The class will also examine the role of architecture and technology and how they are crafted to enhance the overall guest experience. The importance of communication and collaboration across all disciplines and the high professional standards required in every phase in the entertainment industry will be explored. The process of managing creativity, risking taking, fostering a culture of team support and trust, developing presentation skills and providing valuable peer-review will all be part of the curriculum. Students will individually complete a variety of short assignment, research and presentations. Students will also work in teams made up of various disciplines and backgrounds. Assignments will include evaluation of experiences in existing theme parks; proposing a concept for a ride or experience deriving inspiration from a list of options provided by faculty; and developing a design project such as an expansion to an existing theme park, a new restaurant, hotel or other architecture added to an existing complex, a new event or attraction which would include a water, sound and light spectacle or a large scale Disney? parade event. Students and faculty will jointly choose design assignments based on the needs, interest and composition of the class. The constantly evolving nature of the industry will provide opportunities for topics of discussion which will be identified by both faculty and students.

Course Website: <http://www.etc.cmu.edu/learn/curriculum/electives/>

53-371 Role Playing Games Writing Workshop

Fall and Spring: 12 units

Role playing games, mainly traditional pencil-and-paper, but recently to an extent, video RPGs as well have matured over the last 40 years into a viable medium for trans-media storytelling. There is now a generation of novelists, screenwriters, playwrights and TV writers who first felt capable of telling a good story while they were performing as an RPG games master. The course instructor is one of those writers, having won three Game of the Year awards for his RPG stories. Primarily created for writers thinking about writing for games, this class also would be of use to anyone interested in creating interactive stories. Additionally, more traditional linear writers who want to try their hand at ?new media? will also find a home in this class. We will first examine and dissect existing RPGs (mainly using pencil and paper examples, but video game RPGs will also be surveyed) seeking an understanding of both the design of RPGs as well as looking for storytelling ? best practices. ? Once the groundwork has been laid, the class will first be decided into three-person teams. Then, taking a story for an existing RPG world — one from a game that the instructor wrote — analyze a pitch a proposed sequel to that game. Once the pitch has been fine-tuned and approved, proceed to ?flesh out? the new story, delivering, a full treatment for the new story, followed by Act breakdowns, beat sheets, mission arcs, dialogue for select scenes, and one shooting script for a two-minute in game cinematic (if appropriate to the medium). Admission: ETC students, Creative Writing students, and IDeATe students are all encouraged to apply, and seats in the class are reserved for all programs. Final admittance is by permission of the instructor (usually obtained by talking with the instructor and/or submission of a writing sample). Prerequisites: 15-104 or 62-150

53-451 Research Issues in Game Development

Fall: 10 units

This course covers evolving trends in technology and how they can apply to game design. Recent advancements in virtual reality, augmented reality, cloud computing, 4K video streaming, and alternative input devices are changing the way that we create, deliver, and experience games. Students will form collaborative teams to explore these platforms and address design challenges by creating games for them and testing their designs. Prerequisites: 15-104 or 16-223 or 18-090 or 60-223 or 62-150

Course Website: <http://www.etc.cmu.edu/learn/curriculum/electives/>**53-471 Game Design, Prototyping and Production**

Spring: 12 units

This is a lecture and project based course focused on the design and development of video games. The course instruction will cover principals of game design and mechanics, rapid prototyping and iterative design processes, and project management. It will examine business aspects of the industry that impact designs, including demographics, economic models, budgets, and marketing. Students will work in collaborative, cross-disciplinary teams, forming their own "game studios" to tackle design challenges and create games of their own. Teams will engage in hands-on development, and will have roles for artists, programmers, designers, producers and more. Students from all disciplines are encouraged to join.

53-612 Guest Experience and Theme Park Design

Fall: 12 units

Students will research the history of the Themed Entertainment Industry and study key phases ? including conceptualization, design, building, management and delivery ? involved in creating the total themed entertainment experience. The class will focus on the importance of creating the total guest experience. Discussions on story and storytelling will address the different aspects of both franchise and original stories. The class will also examine the role of architecture and technology and how they are crafted to enhance the overall guest experience. The importance of communication and collaboration across all disciplines and the high professional standards required in every phase in the entertainment industry will be explored. The process of managing creativity, risking taking, fostering a culture of team support and trust, developing presentation skills and providing valuable peer-review will all be part of the curriculum. Students will individually complete a variety of short assignment, research and presentations. Students will also work in teams made up of various disciplines and backgrounds. Assignments will include evaluation of experiences in existing theme parks; proposing a concept for a ride or experience deriving inspiration from a list of options provided by faculty; and developing a design project such as an expansion to an existing theme park, a new restaurant, hotel or other architecture added to an existing complex, a new event or attraction which would include a water, sound and light spectacle or a large scale ?Disney? parade event. Students and faculty will jointly choose design assignments based on the needs, interest and composition of the class. The constantly evolving nature of the industry will provide opportunities for topics of discussion which will be identified by both faculty and students.

Course Website: <http://www.etc.cmu.edu/learn/curriculum/electives/>**53-887 Virtual Presence: Art and Applications**

Spring: 12 units

Virtual Presence: Art and Applications is an interdisciplinary graduate-level seminar exploring the use of interactive virtual representations of real places (i.e., the Earth, Pittsburgh, etc.) for educating, engaging, motivating, and/or serving segments of the public. This class will be an extension of the previously taught Telepresence: Art and Applications class. Details: The Carnegie Mellon University Remote Experience and Learning Lab, developer of the EventScope remote experience software, invites students into the lab to learn about virtual presence and participate in the development of new experiences. Software such as EventScope and Google's recently released Google Earth highlight the coming of sophisticated, 3D applications that display satellite data for the public.

General Dietrich College Courses**65-101 Humanities Scholar I**

Fall: 9 units

The Social Impact of War. Tim Haggerty (director, Humanities Scholars Program) War is a continuing aspect of the human condition. This course will introduce students to the manner in which war is conceptualized in modern societies, using readings from philosophy, literature, history and the social sciences to examine how warriors, belligerent societies and cultures describe the benefits and costs of war. The course will focus on the experience of war in the twentieth and twentieth-first century, from the Great War to the War on Terror, while also examining the Cold War and the antecedents to contemporary conflict. This class fulfills the Freshman Seminar requirement for GenEd.

Course Website: <http://www.hss.cmu.edu/hsp/>**65-201 Humanities Scholars III**

Fall: 9 units

65-201, Fall 2015: Ringside: Boxing as Sport and Story Whatever one's opinion of boxing, it endures ? as a sport, and as a story that continues to grip the imagination of writers. To read these stories is to read about race, poverty, violence, and the nature of sports, from the point of view of participant and spectator. As Joyce Carol Oates wrote in the foreword to her book-length essay on the sport, boxing forces us to contemplate not only boxing, "but the perimeters of civilization ? what it is, or should be, to be ? human." We'll read Oates' book On Boxing, and many other works, among them the novel Fat City, and The Sweetest Thing, a memoir by a woman boxer. We'll also view several boxing movies, including Raging Bull, The Fighter, and Million Dollar Baby. Prerequisite: 65-102

Course Website: <http://www.hss.cmu.edu/hsp/>**Heinz College Wide Courses Courses****94-700 Organizational Design & Implementation**

Fall: 6 units

This course draws on insights and knowledge about organizational behavior with an eye toward using such information for managing in complex organizations. It is intended to provide managers with skills and perspectives that will enable them to work successfully in organizations. Specific topics will include work motivation leadership job design biases in managerial decision making understanding group processes building bases of power in organizations managing conflict and the relationship between the organization and its environment.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=26>**94-701 Business English**

Fall and Spring: 6 units

This seven-week course focuses on fundamentals of effective writing. Assignments include employment letters, sales and public relations letters, business proposals, and interoffice correspondence. Since writing is a cumulative skill, emphasis is placed on revising and editing. Students learn how to communicate professionally using appropriate business formats style.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=429>

94-702 Professional Writing

Fall and Spring: 6 units

Communication in written form is an essential element of management. Employers value talent with an aptitude for the effective exchange of information and ideas. This course assumes proficiency in English grammar; instead, it focuses on transferable writing skills pertaining to content, organization, format, clarity and tone. The course challenges students to anticipate the perspectives of various stakeholders in professional situations. Class meetings entail readings, discussions and editing sessions on the following topics: business correspondence, press releases, Web content, policy memos, consulting reports, executive summaries and proposals. Coursework emphasizes precise, concise, persuasive writing based on authoritative sources. Overall, students are expected to demonstrate an interest in professional development beyond simply completing the assignments. Sample documents and writing resources are provided.

94-705 Health Economics

Spring: 12 units

This course will teach the student to use economic analysis to understand critical issues in health care and health policy. We will address issues such as the following: 1. What factors best explain the level and rate of growth of U.S. health expenditures? 2. Does the recent high rate of growth of U.S. health care expenditures make U.S. firms less competitive in international markets? 3. What are some of the likely consequences (intended and unintended) of the proposed reforms to Medicare? 4. Can physicians induce demand for their services? 5. What are the impacts of managed care on the health care system? 6. Do strong affiliations between physicians and health plans hurt competition? The student who successfully completes this course will be able to: 1. Identify the flow of resources in the U.S. health care system how purchasers pay for their services and how providers obtain their revenues. 2. Understand the value of health and health care. 3. Evaluate how health care resources should be allocated. 4. Describe the structure of the health insurance industry explain the incentives facing insurers understand the strategies they use to compete and their impacts on social welfare. 5. Understand the demand for medical care and what role providers play in shaping this demand. 6. Explain the economics of managed care and describe how competition works in health care. Class will consist of lectures and group presentations. Evaluation will include homework problems group projects and exams. This course will interest any individual planning a career in health or related industries. It will also be of interest to students who wish to understand how economics is applied to some of our most prominent and contentious policy issues. Skill. Prerequisites: 90-709 or 90-710

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=32>

94-706 Healthcare Information Systems

Spring: 12 units

In this new era of managed care with its emphasis on improving cost efficiency without risking quality of care information technology has emerged as a powerful force in helping to achieve multiple goals within health care organizations. The explosive advances in information technology combined with the current climate for health care reform has created the need for skilled individuals who can develop understand manage and integrate medical information systems in organizations. This course will explore the concepts and application of major information systems methodologies and approaches in the delivery of modern health care systems. Imaging applications electronic data interchange integrated delivery systems computerized patient records artificial intelligence and expert medical systems decision support systems and Internet based applications are some of the areas that will be covered. A semester-long group project that synthesizes different topics will be a required component of the course.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=133>

94-848 Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal

Spring: 6 units

This course will examine the ways that social media and the ubiquity of mobile phones with good cameras and Internet access are changing how information about development and human rights is gathered, analyzed, and disseminated. We will ask: What are the new possibilities opened up by these technologies? What are the potential pitfalls—e.g., privacy concerns, risks to sources, or the false confidence that we are now able to know everything about what is happening in the world? What are the biggest technical, cultural, and political challenges in this domain? Who is responding to these challenges and what are they doing? And perhaps most importantly, to what extent can advances in technology ameliorate problems that are fundamentally political in nature?

Course Website: <http://heinz.cmu.edu/academic-resources/course-results/index.aspx>

History Courses**79-104 Global Histories**

Fall and Spring: 9 units

Human activity transcends political, geographical, and cultural boundaries. From wars to social movements, technological innovations to environmental changes, our world has long been an interconnected one. Acquiring the ability to understand such transnational and even worldwide processes is an indispensable part of any college education. This course provides students with an opportunity to develop the skills and perspectives needed to understand the contemporary world through investigating its global history. A variety of sections are offered in order to give students the opportunity to choose between different themes and approaches. All sections are comparable in their composition of lectures and recitations, required amounts of reading, and emphasis on written assignments as the central medium of assessment. The sections all aim to help students: (1) master knowledge through interaction with the instructors, reading material, and other students, (2) think critically about the context and purpose of any given information, (3) craft effective verbal and written arguments by combining evidence, logic, and creativity, and (4) appreciate the relevance of the past in the present and future. For descriptions of specific sections, see "First Year Experience" at the Dietrich College General Education Website: <http://www.hss.cmu.edu/gened/>.

79-157 Freshman Seminar: Feast & Famine: Food Supplies and Food Crises in Past & Present

Intermittent: 9 units

This course studies problems of food supplies, food shortages, and famine in the context of social, economic, family, and population systems. We use studies by historians, sociologists, demographers and economists to explore the topic. We use the historical record to show how population systems in East and West functioned to keep resources and needs in balance, and how they often failed. We explore theoretical models that shed light on how and why famines occur, including Malthus's theory of population and, more recently, Amartya Sen's theory of food entitlements. We examine several case studies of famine closely, including the Irish famine of the mid-nineteenth century and the Bengal famine of 1943-44 to understand their causes and consequences. In order to understand how different societies addressed food shortages and famine, we also look at the work of government agencies, charitable institutions, and NGOs [non-governmental agencies] in mitigating famine's effects. The course uses scholarly studies as well as primary sources such as eyewitness accounts, journalists' accounts and government reports to evoke the human experience of famine. Coursework includes assigned readings and discussion, oral reports, and responses to reading assignments. Students will also have the opportunity to carry out individual research projects.

79-162 Freshman Seminar: "Slavery" and "Freedom" in African History?

Intermittent: 9 units

Living in a society still struggling to come to grips with its own history of slavery, American scholars have often imposed words like "slavery" and "freedom" onto African contexts. Such labels have the effect of masking dynamic social institutions in pre-colonial Africa. This course will turn this terminology on its head by delineating the relationship between "slavery" and "freedom," kinship, dependency, and marginality. It will look historically at institutions which are integral to African societies, such as patron-client relationships, marriage, and pawnship. It will interrogate the multiple ways that these institutions functioned before the period of the trans-Atlantic slave trade and the multiple ways that African communities transformed their institutions in response to it. Students will engage a variety of texts, historians' debates in secondary sources, first-hand testimonies of African "slaves" in primary sources, novels which describe the lives of enslaved people in Africa, and recent films which highlight the experiences of enslaved people in Africa and distinguish their condition from enslaved people in the New World.

79-167 Freshman Seminar: Issues in American Environmental History

Intermittent: 9 units

This seminar will focus on major issues in the evolution of the American environment. Much of America's past environmental history has been beset with controversy, as scientists and engineers, health officials, politicians and the public debated about the cause and solution for various environmental problems. This seminar will examine some of the major environmental issues that have evolved over time through a combination of reading, discussion, and short papers.

79-168 Freshman Seminar: The Juvenile Court: Past and Present

Intermittent: 9 units

This course will track the development of an American institution, the juvenile court, from its late 19th century origins to the present. We will integrate historical, legal, sociological, and cultural perspectives in tracking the court's evolution, culminating in a careful look at how recent reform movements are playing out nationally. Readings will include a wide variety of secondary and primary historical sources from different time periods. We will also view and discuss several films (including Frederick Wiseman's 1973 classic, "Juvenile Court"). As opportunities develop, we may also hear from current court practitioners as guest lecturers. The course will be discussion-based. I will do very little formal lecturing, and I expect students to take on increasing responsibility for launching and guiding class discussions as the semester progresses. Evaluation will be based on in-class mid-term and final exams, several oral presentations and brief writing assignments, and contributions to class discussion.

79-178 Freshman Seminar: Body Politics: Women and Health in America

Intermittent: 9 units

Women's bodies have been the sites of long-standing, and sometimes deadly, political battles. This course takes a topical approach to the history of American women's health in the nineteenth and twentieth centuries in order to understand why women's bodies have been such heated sites of struggle. It covers topics such as the history of contraception, abortion, menstruation, sexuality, female anatomy, rape, domestic abuse, menopause, pregnancy, and childbirth. It explores how American culture has constructed these issues over time, while also examining women's organizing around them.

79-198 Research Training History

Fall and Spring: 9 units

This course is part of a set of 100-level courses offered by Dietrich College departments as independent studies for second-semester freshmen and first- or second-semester sophomores in the College. In general, these courses are designed to give students some real research experience through work on a faculty project in ways that might stimulate and nurture subsequent interest in research participation. Faculty and students devise a personal and regularized meeting and task schedule. Each Research Training course is worth 9 units, which generally means a minimum for students of about 9 work-hours per week. Prerequisites/restrictions: For Dietrich College students only; minimum cumulative QPA of 3.0 (at the time of registration) required for approved entry; additional prerequisites (e.g., language proficiency) may arise out of the particular demands of the research project in question. By permission of the relevant professor and the Director of Undergraduate Studies. Students sign up for these courses through both the History Department and the Dean's Office.

79-200 Introduction to Historical Research

Fall and Spring: 9 units

Introduction to Historical Research acquaints students with how historians practice their craft in interpreting events from the past. The emphasis is on learning to supplement standard secondary accounts of an event with primary sources such as memoirs, government documents, speeches, literary sources, news accounts, music, maps, and images. The goal is for students to develop a familiarity with the skills required to identify a research topic, find and work with many kinds of sources, create a strong thesis statement, design a persuasive paper, and produce a properly formatted and well written research paper.

79-201 Introduction to Anthropology

Fall and Spring: 9 units

Cultural anthropologists "make the strange familiar and the familiar strange," attempting to understand the internal logic of cultures which might, at first glance, seem bizarre to us, while at the same time probing those aspects of our own society which might appear equally bizarre to outsiders. In doing so, anthropology makes us more aware of our own culturally-ingrained assumptions, while broadening our understanding of the possibilities and alternatives in human experience. This course will use ethnographic writings (descriptive accounts of particular cultures), as well as ethnographic films, to investigate the ways in which diverse societies structure family life, resolve conflict, construct gender relations, organize subsistence, etc. We will assess the advantages and pitfalls of comparing cross-cultural data, analyze the workings of power within and between societies, and consider the politics of cultural representations. We will also discuss the anthropologist's relationship to the people s/he studies, and the responsibilities inherent in that relationship. Throughout the course, students will learn the importance of an historical perspective on culture, looking at how and why societies change, and considering how we, as anthropologists, should assess these changes.

79-202 Flesh and Spirit: Early Modern Europe, 1400-1750

Intermittent: 9 units

This course examines European history from the Black Death to the French Revolution, a period known to history as the "early modern" period. That is, it marks a period in European history that was not quite medieval, and yet not quite modern. Many features of modern society, such as the nation-state, free-trade economies, religious pluralism, scientific rationalism, and secular culture trace their origins to the early modern era, yet the period was also marked by important continuities with the Middle Ages. During this course, we will explore how Europeans re-imagined their world in its transition from the medieval to the modern. Topics to be considered will include the "renaissance" of the arts, the problems of religious reform, exploration and colonialism, the rise of science, and the expansion of the state. Through these developments, we will focus on Europeans' changing notions of the human body, the body politic, and the natural world, as well as their re-interpretations of the proper relation between the human and the divine, the individual and the community, and the present and the past.

79-203 Social and Political Change in 20th Century Central and Eastern Europe

Intermittent: 9 units

During the course, students will develop their knowledge of the geographical, cultural, and political characteristics of 20th century Central and Eastern Europe. By analyzing the sweeping political changes in the region that had occurred in a relatively short historical time, students will better understand the emergence of nationalist movements and radical political ideologies such as socialism and fascism during the interwar period against a backdrop of regional histories of centuries-long inter-ethnic cohabitation. They will also assess to what extent these earlier histories continued to subtly influence the social landscapes of post-1945 Central and Eastern Europe, thus complicating the processes of socialist modernization that the new regimes tried to implement in the region under the close scrutiny of the USSR. Course materials will include not only historical and anthropological readings, but also historical documents, literary texts and films from the region. The assignments will consist of regular participation in class discussions, weekly responses to the readings, two critical essays (each 5-6 pages long), and a final exam.

79-205 20th Century Europe

Intermittent: 9 units

This course surveys the history of Europe from 1900 to 2000 and beyond. While it covers major political trends and social/economic changes of the last century, it concentrates on the following themes: the extraordinary violence of the two World Wars — and their continuing impact on politics, society, and culture; social and political movements/regimes of the Far Right and of the Socialist/Communist Left; the rise and crisis of the European welfare state and of the European Union; reactions to U.S. power and to Americanization; cultural and political controversies surrounding Islam and Muslims in Europe today.

79-207 Development of European Culture

Intermittent: 9 units

This course surveys the evolution of European culture from 1500-1950. It defines 'culture' broadly to include not only philosophy, literature, and art but also science, manners, sexuality, morality, and religion. Lectures, readings, and discussions will introduce students to European thinking and writing on these questions. The course will place cultural change in the context of politics and society. Readings will include historical studies, novels, plays, and memoirs. Assignments will include six 3-page essays and one 6-page essay.

79-210 Identity, Nationhood, and State

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. This broad introductory course to general history through the prism of literature and politics aims at appreciating humanism and identity from the distant past on. 1. It discusses the significance of language and speech aptitude as a primordial and universal trait upon which rests the possibility of association and organization. This aptitude has made humans history conscious. 2. It explores some basic facts about the pre-19th century Western tradition of governance and the place of the individual within it, along with the expansion of these European states into the world in the aftermath of the maritime navigation and colonial conquest. An emphasis is placed on the pivotal European movements of the Renaissance and Enlightenment. The first, with its humanism in the 16th century, promoted a sense of identity associated with the language spoken in one's area and the rise from the old medieval notion of suzerainty of the local gentry over local communities to the sovereignty of the monarchy of the area, thereby the nation state. The second, the 18th century Enlightenment, led to reforms and revolutions. These transformations, including the growth of literacy, have significantly marked Europe and subsequently the rest of the world that experienced European domination or influence. All this has resulted in the making of broad communities of European language speakers who are not of European descent.

79-211 East Asia in the World, 1600-Present

Intermittent: 9 units

The aim of the course is to provide a broad understanding of the place of East Asia in the world, and of the challenges that each state (China, Japan, Korea) has faced at home and abroad since 1600. Together we will examine the different ways the three states responded to internal and external crises and transformed into modern nationhood. We will also consider interpretations of the past that continue to impact how East Asians today perceive themselves, their countries, and international relations. Some of the topics covered will include globalization, imperialism, nationalism, gender politics, and the role of historical memory (as in Nanking, Hiroshima and the Korean War). Historical sources will include primary and secondary documents, pictures, films and memoirs.

79-217 The War in Vietnam

Intermittent: 9 units

The Vietnam War, the first war to be televised, is one of the most controversial events in the post-World War Two history of the United States. What began as a limited advisory mission aimed at saving the "free" nation of South Vietnam from Communism soon escalated to full-scale warfare that provoked widespread domestic protest and resistance to and evasion of the Draft. Eventually, the strategic basis for U. S. foreign policy in general was called into question. The U. S. withdrew combat troops in 1973, and Saigon fell to the North Vietnamese in 1975 as America watched from its living room. This course covers the war in Vietnam from the 1950s through the fall of Saigon in 1975 and its legacies. It will examine not only the military and political aspects of the war, but also the social and cultural consequences in the U. S. during and after the war.

79-218 United States and the World

Intermittent: 9 units

Combining lecture and class discussion of primary source documents, this course will examine the United States' use of hard and soft power around the world since 1877. It will blend high-level foreign affairs with the daily lives of ordinary Americans and the lives of other peoples, and closely examine specific commodities like Hawai'ian pineapples, West African chocolate, Middle Eastern oil, and China-made iPhones.

79-221 Development and Democracy in Latin America

Intermittent: 9 units

"Development" and "democracy" are two keywords in the contemporary world. This course will use the modern history of Latin America and the Caribbean (1800s-present) to examine what these terms have meant in different times and places. Latin America is marked by major bio-cultural diversity; a long history of economic "globalization;" and revolutionary political transformations. In recent years, most Latin American nations have seen economic "growth" and convene peaceful elections, but enormous inequalities persist and environmental problems loom large. We will try to make sense of this reality via historical analysis. In so doing, we will consider long-standing debates over forms of government, economic models, the rights of citizens, the role of government in social welfare, and environmental sustainability. Course materials include scholarly writing, historical documents, current events, music and film/video. The course is discussion-oriented with minimal lecturing.

79-222 Between Revolutions: The Development of Modern Latin America

Intermittent: 9 units

When the Haitian Revolution began in 1789, everything south of the newly created United States was under European colonial rule, slavery was an established institution, and the Catholic Church held considerable power over the daily lives of people. However, when the Mexican Revolution began in 1910, Spanish and Portuguese colonialism had collapsed along with slavery, and the power of the church had greatly diminished. New societal institutions emerged that reflected novel ideas about the role of secular nation-states, "free market" economies, and the meanings of "civilization." This course will use scholarly writings, fiction, film, and video to analyze the profound changes that took place in Latin American society during and between these two important revolutions. We will pay attention to the lives of both elites as well as the "everyday" people who helped to shape the region's history.

79-223 Mexico: From the Aztec Empire to the Drug War

Intermittent: 9 units

This course provides a survey of Mexican history and culture over a variety of periods, from the rise of the Aztec empire, to Spanish conquest and colonization, to national independence, to the Mexican Revolution and contemporary Mexico. A wide range of topics will be addressed, such as: race, ethnicity, and indigeneity; state formation and politics; national identity and the politics of memory; migration and the border; and the drug war. Students will discuss historical and anthropological scholarship on Mexico, but will also consider cultural documents of various kinds, like Mexican music, art, and food.

79-224 Mayan America

Intermittent: 9 units

This course will explore the history and culture of the Maya from before the European conquest of the Americas to the present. After a survey of ancient Mayan society and of the European conquest of Mexico and Central America, we will consider the experience of the indigenous Maya under Spanish colonial rule and under the rule of Latin American nation-states in the nineteenth and twentieth centuries. Finally, we will cover the recent history of political conflict and military repression in Guatemala, the Zapatista uprising in southern Mexico, and increasing Mayan migration to the United States. Drawing upon the varied perspectives of archaeology, cultural anthropology, and social history, this course will explore several recurrent themes in Mayan America, such as: conquest, adaptation and resistance; indigenous political and communal organization; popular religion, prophecy and apocalypse; Mayan cultural and ethnic identity; "tradition" and "modernity"; state violence and human rights; and indigenous political and cultural mobilization at the local, national, and transnational levels.

79-225 West African History in Film

Intermittent: 9 units

West Africa is a vibrant, diverse, and rich region, which has had the largest influence demographically, culturally, socially, and linguistically on the Americas. This course will examine West Africa's history from the pre-colonial to the independence period. It will cover such topics as states vs. stateless societies, urbanization, trans-Saharan trade, Islamization, European interaction, the trans-Atlantic slave trade, colonialism, cash crops, missionaries, nationalism, and independence. Students will understand how this dynamic region changed over time as a result of internal factors, such as state formation, as well as external factors, interaction with Muslim and European traders. Students will also be exposed to the variety of sources used by historians to reconstruct West Africa's rich history. The course will use historical films by some of West Africa's most famous filmmakers, such as Ousman Sembene, to illustrate the diversity of the region and its historical change over time. Course includes two class meetings and mandatory film screenings on Tuesdays from 6:30-9:20pm.

79-226 African History: Earliest Times to 1780

Intermittent: 9 units

A beginning point for this course will be the question: how do historians reconstruct history when few written sources are available? Breaking disciplinary boundaries, the course will draw on linguistics, "climateology," archaeology, and anthropology to reconstruct dynamic social, cultural, political, and economic processes in Africa before the arrival of Europeans and before the availability of written source materials. When written sources are available, the course will interrogate them to illuminate the changes that occurred in African societies during the early period of contact with Europeans. Lastly, by focusing on long-term processes, such as economic specialization, urbanization, and Islamization, the course will begin to put the slave trade in an African-centered perspective.

79-227 African History: Height of Trans-Atlantic Slave Trade to the End of Apartheid

Intermittent: 9 units

The course is designed to give students an understanding and appreciation of African history and culture from the "inside out." Though it deals with the period of European expansion in Africa, it is centered on African language/ethnic groups, villages, and individuals as historical actors who daily make collective and personal decisions to pass down, innovate, and borrow practices, technology, spiritual systems, etc. in the face of social, political, and economic realities. The course is also designed to get students thinking critically about how historians select and interpret sources to construct and reconstruct history at these different levels.

79-229 Origins of the Arab-Israeli Conflict, 1880-1948

Intermittent: 9 units

This course considers the historical origins of the contemporary Arab-Israeli conflict, beginning with the decline of the Ottoman Empire and the rise of Arab nationalism and Zionism in the late 19th century and emphasizing the period of the British Mandate over Palestine (1920-1948). Students will move beyond the textbooks to explore primary source documents, maps, photographs, biographies and historical testimony. For five weeks in the middle of the semester, students will immerse themselves in an extended role-playing exercise, "The Struggle for Palestine, 1936," an elaborate simulation game linked to Barnard College's "Reacting to the Past" program. Students portraying British examiners, specific Arab and Zionist characters and various journalists will recreate the activities of the 1936 Royal Commission which came to Palestine to investigate the causes of an Arab rebellion and Arab-Jewish strife. This historical reenactment experience constitutes an exciting pedagogical opportunity for delving deeper into the topic material than regular coursework allows. All the role-playing will take place during regular class time, but students should be aware that they will need to devote outside time for preparation and research. Outstanding attendance is also a requirement. Regular classroom activity resumes at the end of the five weeks. The goal of the course is for students to develop a nuanced understanding of the varying goals and priorities of all the actors in Mandate Palestine. Running throughout the course is the question, was peace ever possible?

79-230 Arab-Israeli Conflict and Peace Process since 1948

Intermittent: 9 units

This course begins in 1948 with the establishment of the State of Israel, the Palestinian dispersal and the first of many Arab-Israeli wars, and continues up to the present time. Emphasis is on primary source documents and other source material beyond the textbook such as maps, film, media, photographs, autobiographies and biographies. The examination of the many facets of the Arab-Israeli and Palestinian-Israeli conflicts is accompanied by attention to the search for peace and its frustration. The semester culminates in a sustained role playing exercise simulating Arab-Israeli negotiations. Is peace even possible?

79-231 American Foreign Policy: 1945-Present

Intermittent: 9 units

This course provides an introduction to the study of U.S. foreign policy. Its main focus will be on problems and possibilities confronting the world during the Cold War as well as global political changes in the post-Cold War era and since 9/11. Important foreign policy strategies which will be discussed include the strategy of containment, NSC-68, the Eisenhower-Dulles "New Look," the Kennedy-Johnson "flexible response," "détente," the democratic peace, and contemporary approaches to combating global terror. Theoretical readings in history and political science will be used as analytic filters to assess both scholarly evaluations of American foreign policy and key historical episodes.

79-232 Arabian Peninsula Environmental History

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. This course will look at the history of the Arabian Peninsula from a fresh perspective, examining human/environmental interactions over a long stretch of time. In contrast to the way that Arabian history is typically taught in academia, this course will take the pre-Islamic period of Arabian history (al-jahiliyya) as seriously as the post-Islamic period, and will focus on continuities between the two periods as much as discontinuities. What is more, while conventional histories of the Arabian Peninsula focus on political and religious affairs, this course will try to understand Arabian history on a deeper level by focusing on the lifeways of the Arabian people, including pastoralism, oasis "bustan garden" agriculture, fishing and pearling, and shifting patterns of long-distance trade. What is more this course will draw heavily from material from other disciplines, especially medical sciences, to better understand patterns of change over time. Finally, this course will examine to what degree these older patterns of human/landscape interactions are still valid for the Arabian Peninsula today, which has undergone a transformation almost unparalleled in world history due to the discovery natural gas and oil.

79-233 The United States and the Middle East since 1945

Intermittent: 9 units

This course begins by introducing students to the Middle Eastern priorities and policies which the US inherited from the British in the aftermath of the Second World War. The focus then moves to American interests and involvement in the region from the Cold War through today, with special attention to recurrent historical themes. Topics include the US role in the Arab-Israeli conflict and peace process, the role of oil, politics and conflicts in the Persian Gulf, the impact of 9/11 on American foreign policy in the Middle East, and selected case studies of US political and military intervention there. Readings and discussion progress with a dual goal in mind: to understand American foreign policy interests in the Middle East, and to understand the forces and nuances endemic to the region itself. Students will learn how to analyze primary source documents, such as presidential speeches and UN resolutions.

79-235 Caribbean Cultures

Intermittent: 9 units

This course will examine the cultures and societies of the Caribbean focusing on their colonial past, their current positioning in the world, their social structure, cultural patterns and current transnationalism. Using social history, film and music we will explore the topics of race, class, family, gender, religion, national identity and underdevelopment. Comparative research projects will provide concrete instances of the differences and similarities between the Anglo-Caribbean, Franco-Caribbean, and Hispanic Caribbean. This course is open to all students.

79-236 Introduction to African Studies

Intermittent: 9 units

This course is designed to give students an overview of historical, political, social and economic developments in Africa. The course will begin with an examination of selected ancient African kingdoms. Pre-colonial African political systems will be discussed. That will be followed by discussion of Africa during the middle ages. Colonialism, nationalism, and post-colonial state will be covered. Vital issues such as democratization, conflict resolution, human rights, globalization, and Pan-Africanism will also be discussed.

79-237 Comparative Slavery

Intermittent: 9 units

The past few years have seen a proliferation of major motion pictures about enslavement, particularly Django and Twelve Years a Slave. They have all depicted enslavement in the context of the US South. This course will examine the enslavement of Africans and people of African descent from a comparative perspective, investigating labor organization on rice, sugar, cotton, tobacco, and indigo plantations, gender, class, as well as the experiences of enslaved children in the Americas, the Caribbean, and parts of Africa. Students will learn to critically read and analyze secondary sources, conduct independent research in primary sources. We will also view and discuss different representations of enslaved societies in popular media, including film.

79-240 The Development of American Culture

Intermittent: 9 units

This is an introductory survey of American history from colonial times to the present. The course focuses on cultural history instead of the more traditional emphasis on presidents, wars, and memorizing facts or timelines. The major theme of the course is the changing meaning of freedom over three centuries. Required readings include several short books, historical documents, and a study of the concept of freedom. There is no textbook; background facts and events are covered in lectures to provide students with context needed to think about and understand America's cultural history. Assignments include exams and essays.

79-241 African American History: Africa to the Civil War

Intermittent: 9 units

This course examines a series of topics—economic, demographic, social, cultural and political—in African-American history from the beginning of the transatlantic slave trade to the Civil War. In addition to changes in race relations, this course also explores the internal experiences of black people within the framework of larger socioeconomic, cultural, and political processes in U.S. history. Although the course includes a general text, assigned readings revolve around detailed studies of particular topics (e.g., work, family, and religion) or chronological periods (e.g., the colonial, revolutionary, and ante-bellum eras).

79-242 African American History: Reconstruction to the Present

Intermittent: 9 units

This course examines the black experience from Reconstruction to the present. Along with shifting class, gender, and race relations, this course also examines the development of the African American community within the broader context of socioeconomic, cultural, and political processes in U.S. history. Although the course includes a general text, assigned readings revolve around detailed studies of particular topics (e.g., work, family, and religion) or chronological periods (e.g., the Great Migration, Depression, World War II, and the Civil Rights Era).

79-243 The Civil War in American Memory

Intermittent: 6 units

The American Civil War remains among the most cherished and fought over stories in American history. This class explores those debates. Was the war fought over slavery? Was the Confederate cause noble? Did the North oppose slavery? Why do Americans flock to reenact the Civil War? What does it mean to fly the Confederate flag? Tackling ongoing debates in the news today, including recent events in Charleston, we'll trace the roots of those events back to the American Civil War. And we'll strive to understand why the war continues to be one of the most defining moments in U.S. history - 150 years later.

79-244 Women in American History

Intermittent: 9 units

This course is a survey. It examines U.S. history through the eyes of women and gender. It begins in the colonial era (1600s) and runs chronologically to the present. It covers topics such as witchcraft, the story of Pocahontas, women's work, motherhood, slavery, and much more. We will look at the lives of individual women, as well as trends among women, paying attention to questions of race and class. At the same time, we will explore changing concepts of gender, meaning ideas about what women are or should be. Finally, the course asks: how different does American history look when we factor in women and gender?

79-245 Capitalism and Individualism in American Culture

Intermittent: 9 units

This small discussion course traces ideas about individualism and capitalism in the U.S., from colonial times to the present. We will focus on three main themes: 1) the relationship between capitalism, work, and identity; 2) changing definitions of success and failure; and 3) the historical origins of students' attitudes toward 1 & 2. In short, we will study the economics and emotions of the American dream: how class, race, gender, occupation, and ambition shape our identities. Readings include "The Autobiography of Benjamin Franklin," studies by Alexis de Tocqueville and Max Weber, writings of Frederick Douglass, Ralph Waldo Emerson, Herman Melville, Henry Thoreau, Charlotte Perkins Gilman, Andrew Carnegie's classic essay "Gospel of Wealth," Arthur Miller's "Death of a Salesman," and Malcolm Gladwell's "Outliers." Grading is based upon a readings journal, participation in discussion, three short essays and a longer final paper.

79-246 Industrial America

Intermittent: 9 units

This course examines the transformation of America into an urban industrial society during the 19th and 20th centuries. The transformation of work, culture, and politics will receive close attention, but the course will primarily focus around how workers defined their own labor and changes in the culture of work over time. This course will investigate how race, class, and gender informed workplace relations as well as how immigration and migration changed the nature of American work. Through lecture, discussion, and three short writing assignments we will uncover how workers defined America.

79-247 The Civil War Era: 1848-1877

Intermittent: 9 units

This course examines America's pivotal middle period, a period of rising sectional tensions, bloody civil war, slavery's end, and protracted debates about the promise and limits of equality. The first third of the class traces the causes of the war, the middle third dwells on the devastating war itself, and the final third explores the aftermath of the war, when Americans clashed over how to reunite and over what the meaning of freedom for four million emancipated slaves ought to be. Sometimes known as "America's unfinished revolution," the Civil War continues to resonate in American society today. The course concludes by considering current questions such as flying the confederate flag, slave reparations, and others.

79-249 20th Century U.S. History

Intermittent: 9 units

The twentieth century marked the rise of the United States as a global power. By the end of the century, the United States had achieved economic, military, and political dominance. The United States also made great strides in expanding political and civil rights for workers, women, African-Americans, and gays and lesbians. This course explores the cultural implications of these developments on the generations of American people who came of age in the twentieth century. It assesses both the triumphs and tribulations of twentieth-century life. We will analyze the continuities, contradictions, and conflicts in American history, especially in regard to the nation's dueling political ideologies: conservatism and liberalism. Special attention will be given to the evolving relationship among the state, the corporate sector, and ordinary people. Topics include: the Progressive Era, the Great Depression, World War II, the Cold War, Civil Rights, Vietnam, and the New Conservatism.

79-251 India/America: Democracy, Diversity, Development

Intermittent: 9 units

India and the United States, two of the world's largest democracies, have long been interconnected-culturally, economically, and politically. From yoga and bhanga to outsourcing and nuclear politics, Indo-American relations have become increasingly important to both countries. This course will focus on connections between the United States and India in the twentieth century. Specific topics will include the Indian American struggle to gain American citizenship; American involvement in the Indian independence movement; the influence of Gandhian nonviolent civil disobedience on Dr. Martin Luther King, Jr. and the American civil rights movement; Indo-American relations during the Cold War; American economic aid to India; outsourcing and other recent economic linkages; the history of Indian students in the United States; and cultural connections including food, dress, music, dance, and Bollywood/Hollywood.

79-252 Recent U.S. History, 1945-Present

Intermittent: 9 units

This course will explore the social, cultural, and political history of America since World War II. Topics include: the dawn of the nuclear age, the Cold War, the Korean and Vietnam wars, the civil rights movement, the women's movement, the counter culture, the energy crisis of the 1970s, the rise of environmentalism, and the turn toward conservatism in the 1980s. We will use music, film, television, and literature as evidence of cultural change in American society during the past 70 years.

79-253 American Massacres in History and Memory

Intermittent: 6 units

In this course we will investigate 19th century massacres in the American West, examining the causes and aftermath of violence between competing communities divided by ethnicity, class, religion, gender, and civil war. By the end of the class we will have examined some of America's most tragic and best-known massacres - from the Alamo (1836) to Little Big Horn (1876) to Wounded Knee (1890) - and will have achieved a better understanding of their historical contexts and influence, as well as their transnational implications and repercussions for society today.

79-254 The Jewish Diaspora in Latin America

Intermittent: 9 units

This course explores the history of the Jewish presence in Latin America and the relevance of the Latin American experience in shaping Jewish identity. We will survey the presence of Jews in Latin America from the time of the conquest to the present. Among the topics we will consider are: the Inquisition and crypto-Jews in Latin America; Jewish immigration in early nineteenth-century Latin America; relationships between Jews and non-Jews including other minority groups such as Arabs; relations between Ashkenazic and Sephardic Jews; Jewish cultural life and political activism in the context of the rise of modern-nation states, revolutions, military dictatorships and violence; antisemitism; and the influence of contemporary politics in Latin America on Jewish life.

79-255 Irish History

Intermittent: 6 units

This course surveys Irish history from the earliest human settlements until the present day, with emphasis on the period since the sixteenth century. Our main objective is to understand the sources of conflict in modern Ireland. In order to do that, however, we look at a number of topics such as the role of religion in Irish society; the causes of population growth, movement, and decline; changing forms of protest; and the formation of rival myths of the Irish past and its meaning.

79-256 20th Century Germany

Intermittent: 9 units

This course will trace the evolution of German politics, society, and culture from 1914 through 2000. It will consider the causes and consequences of the huge upheavals and catastrophes that Germany went through in these decades: the First World War, political revolution, National Socialism, the Second World War, the Cold War division of Germany and Germany's reunification. A major theme of the course will be Germans' artistic responses (in visual arts, fiction, and film) to their country's turmoil, crimes, and disasters in the 20th century. In addition to a survey history, students will read several novels, a memoir, eyewitness accounts, and one historical monograph. Writing requirements will include two 7-page essays on readings and a take-home final.

79-257 Germany and the Second World War

Intermittent: 9 units

This course examines the Second World War from the perspective of the country that was central to it in every way. The course will cover: Hitler's ideology, war plans, and military strategy; the military/technological history of the War in Europe and North Africa; the role of the SS; the Holocaust; the occupation of Europe and Resistance movements; the political, social, and economic history of the Third Reich, including popular opinion, the German Resistance, and the use of slave labor in factories and on farms. Readings will include historical studies, a novel, and a memoir/diary. Students will watch four films about the war on Thursday evenings (these will be the only Thursday evening sessions of the course).

79-258 French History: From the Revolution to De Gaulle

Intermittent: 9 units

This survey course looks at French society and culture from the period after the French Revolution (roughly 1815) to the Nazi invasion of 1940. We first look at the multiple impacts of the Revolution on French society. We try to understand some of the lasting features of nineteenth and early-twentieth century France by studying the lives of different social groups including workers, peasants, and members of the elites. We follow the continuing problem of French political instability in the nineteenth century, trying to understand the deep rifts that divided different groups of French people from one another. We look at the devastating impacts of World War One and the Great Depression, and end with the collapse of France in 1940. Coursework is based on the use of works of fiction, film, personal memoirs, and art as well as historians' writings. Written work includes papers and in class tests.

79-259 France During World War II

Intermittent: 9 units

This course surveys the history of French society, economy, and culture in the years 1939-1945 focusing on problems that the war and German occupation presented. Understanding life under the German Occupation and the collaborationist government in Vichy also requires us to look back at major political, social and economic conditions of the 1930s that divided the French people. We use film and personal memoirs as well as recent historical studies to recreate a sense of life during the war, and try to answer such questions as: What accounts for the French military collapse of 1940? Which groups of French men and women benefitted from collaboration with Germany? How did France's collaboration in the Holocaust come about? We also consider how the French people have tried to come to terms with their wartime experience since the 1940s. This course is open to all students. Students can access films both through the video collection in Hunt Library and through evening screenings [days and times to be determined].

79-261 Chinese Culture and Society

Intermittent: 9 units

This course is a broad introduction to the history and society of pre-Modern China, from the beginning of its recorded history to the eve of major western impact. China is often said to be the world's longest enduring civilization. But what does that mean? What is it that makes Chinese civilization distinct? And was China prior to the arrival of the west "traditional" or was it instead marked by dynamic political, social and economic change? Over the course of this class, we will address these and many other issues. Special attention will be paid to state building, philosophical/religious traditions (including Confucianism, Buddhism and Daoism), material culture, intellectual history, social change, gender and the role of women, economic development, and China's relationship with the surrounding societies of East Asia, Inner Asia, and Tibet.

79-262 Modern China

Intermittent: 9 units

This course is an introduction to major themes in twentieth-century Chinese history, including the transition from empire to nation, revolution, social change and modernization, western and Japanese imperialism, the rise of the party-state, Chinese socialism, economic liberalization and the so-called "Chinese Dream." The first half of the class is devoted to the period between the fall of the imperial system and the founding of the People's Republic of China (1911-1949). If the victory of the Chinese Communist Party and development of the socialist state are to be considered in historical context, it is necessary to first understand the political, cultural, economic and intellectual currents that immediately preceded them. During the second half of the course, we will examine the Maoist period (1949-1976). We will investigate the Chinese Communist Party as both a state-building institution and an engine of social transformation, and consider the tensions these dual roles produced. Finally, we will look at the Reform Period (1978-present), and reflect on a newly robust China's attempts to come to terms with its own recent past and what the consequences might be for both China and the world.

79-264 Tibet in History and Imagination

Intermittent: 9 units

This course is an introduction to the history and culture of Tibet and the Tibetan Plateau. For a sparsely populated region lying atop the Himalayan Mountain Range, Tibet has long held a remarkable hold on the imaginations of outside observers. In this class, we will go beyond the many mythologies and stereotypes that have shaped perceptions of Tibet and Tibetans. Alongside the chronology of Tibetan history, we will investigate what it is that makes Tibetan civilization distinct. We will pay close attention to the foundations and development of Tibetan Buddhism and examine its centrality not only to the social, economic and spiritual life of Tibetans but also in the development of Tibet's unique political culture, including the institution of the Dalai Lama. Other themes will include Tibet's relationship to the surrounding civilizations of eastern, southern and inner Asia; western imperialism and western fascination with Tibet; and Tibet's incorporation into the modern Chinese state. We will also address the current controversy over Tibet's international status, the prospects for a political solution, and the state of Tibetan civilization in the twenty-first century. Finally, we will consider Tibet's continuing ability to capture the imagination of peoples around the world.

79-265 Russian History: From the First to the Last Tsar

Intermittent: 9 units

This course covers a broad sweep of Russian history beginning with the first settlements of tribal nomads in the ninth century and ending with the fall of the 300-year-old Romanov dynasty in 1917. Our course profiles how the Russian state was formed and how its territory expanded to become a mighty empire. Over the centuries, we make the acquaintance of Mongol marauders, greedy princes, and peasant rebels, as well as Ivan the Terrible, Peter the Great, and the long succession of reformers and reactionaries who occupied the Russian throne. We explore terrorism, general strikes, and development of the revolutionary movement that ultimately brought down the Tsar in 1917.

79-266 Russian History: From Communism to Capitalism

Intermittent: 9 units

This course covers a broad sweep of Russian history from the socialist revolution in 1917 to the collapse of the Soviet Union in the 1990s. Spanning almost a century of upheaval and transformation, the course examines the October revolution in 1917, the ruthless power struggles of the 1920s, the triumph of Stalin, the costly industrialization and collectivization drives, the battle against fascism, and the "wild west" capitalism and collapse of the social welfare state. The course provides essential background for anyone interested in understanding Russia's place in the world today and its relationship with the West.

79-267 The Soviet Union in World War II: Military, Political, and Social History

Intermittent: 9 units

On June 22, 1941, Hitler invaded the Soviet Union. German troops quickly reached the hills above Moscow, surrounded Leningrad in the longest running siege in modern history, devastated the country's economy, and slaughtered millions of Soviet civilians. Over 26 million Soviet citizens died in the war. Eventually, the Red Army came back from defeat to free the occupied territories and drive Hitler's army back to Berlin. Using history, films, poetry, veterans' accounts, documentaries, and journalism, this course surveys the great military battles as well as life on the home front. It highlights the rise of fascism, the Stalinist purges of the Red Army, and the Nazi massacres of Soviet Jews, peasants, and partisans. Occasional required evening film screenings.

79-268 World War I: The Twentieth Century's First Catastrophe

Intermittent: 9 units

This course offers a comprehensive retrospective of the First World War (1914-1918). The course will cover the diplomatic, military, political and social history of the war. Guiding questions will be: How did a containable crisis between Austria-Hungary and Serbia become the most murderous war Europe had ever experienced? How did the war spill over into the Middle East? Why did the US enter the war? Why did every General Staff follow unimaginative military strategies that turned the war into a bloody horror for soldiers? What was the role of women and women's rights on the home front? How did the war lead to two major revolutions and the collapse of four powerful empires? Readings will include five or six outstanding new historical studies as well as internet search/reading in preparation for class debates. Students will write three 7-8 page essays and participate in two debates.

79-271 Russian Studies Topics

Intermittent: 6 units

A1- Literary Culture of 19th Century Russia The purpose of the course is to give students an introduction to the cultural environment of the Imperial Russia through the works of major 19th century Russian writers. We will read and analyze some masterpieces of Russian fiction, including works of Pushkin, Lermontov, Gogol, Turgenev, Dostoevsky, Tolstoy, and Chekhov. Emphasis will be made on how these brilliant classics reflected turbulent history of the 19th century Russia. A2- Literary Culture of 20th Century Russia This mini-course focuses on Russian prose and poetry of the early 20th century. Readings will include the "proletarian" writings of Maxim Gorky, "symbolism" of Alexander Blok, "futurism" and "modernism" of Vladimir Mayakovsky, as well as works of some other authors. We will discuss issues important to the 20th century Russian Cultural History such as the role of intelligentsia in Russian Revolution, the content and method of Russian decadence, symbolism, and modernism, as well as imprisonment, liberation, and exile that became so important for many writers and poets.

79-272 Iberian Encounters: Muslims, Christians, and Jews in Spain

Intermittent: 9 units

In Medieval Spain, Islam, Judaism and Christianity coexisted in a situation distinguished by cooperation and exchange, as well as by friction, rivalry and violence. In this course, we shall explore the complexity of this historical encounter, as well as its role in shaping debates over modern Spanish identities and historical memory. We shall discuss topics such as: Inter-ethnic collaboration and violence; Jewish-Christian disputations; the exclusion and expulsion of religious and ethnic minorities; debates over the marketing of Spain's multiethnic past, as well as North African immigration in contemporary Spain. Historical documents, literary texts, film, musical traditions, as well as contemporary political and cultural debates, will be discussed to enhance familiarity with the topic.

79-274 19th and 20th Century Russia: Society, Art, Music and Theater

Intermittent: 9 units

This course will focus on the most significant historical events in 19th and 20th century Russian societies, and track their influence on the development of Imperial, Soviet and post-Soviet culture and cultural institutions. Students will learn about famous giants of Russian literature, painting, music, and drama who gained global recognition. The course, which includes secondary readings, primary documents, and films, will allow students to achieve a critical understanding of contemporary Russia.

79-275 Introduction to Global Studies

Intermittent: 9 units

"Globalization" is a familiar term that is often used to invoke the idea that places around the world are rapidly becoming more interconnected. This is so, but it is also true that this is far being from a simple or harmonious process. Rather, "globalization" involves a wide range of uneven and disputed cultural, political, economic, and social developments that often influence one another but vary markedly in their significance, impact, and intensity. Economic crisis, impoverishment, rising inequality, environmental degradation, pandemic disease, and militant ethnic, religious, and nationalist movements are just as much a part of the contemporary global landscape as are technological innovation, instantaneous communication, shifts in the global division of labor, the creation of new wealth and knowledge, the promotion and defense of human rights, and the rise of cosmopolitan values and perspectives. This course introduces you to important ways of thinking about globalization and will acquaint you with the kinds of research, evidence, and information upon which these kinds of thinking rely. It serves as a foundation for further study of the contemporary world in advanced Global Studies courses.

79-276 Beyond the Border

Intermittent: 6 units

In this course we will consider the place of the border in the making of the Americas. Our explorations will be far-ranging: from the initial encounters of Columbus with indigenous Taino, to contemporary debates over migration and border control; from the making of borderlands to the shaping of border identities; from history to ethnography, literature, music, visual arts and film. The first part of the course will focus on the ramifications of the conquest and colonization of the Americas, and specifically on the power of colonial narratives used to inscribe borders and frontiers in the colonial imagination—to define "civilization" and "barbarism," self and other. After a discussion of indigenous counter-narratives, we will move on to the second part of this course, an exploration of how what is now known as the southwestern United States and northern Mexico were transformed from borderlands into bordered lands, over the course of the nineteenth and early twentieth centuries. In the final part of the course, we will move through and beyond the U.S.-Mexico border, to consider how "border thinking" helps to illuminate the frontiers of language, race, ethnicity, nationalism, and religion in the contemporary Americas.

79-278 Rights to Representation: Indigenous People and their Media

Intermittent: 9 units

For decades anthropologists have been "picturing" others, in images as well as in words. This course explores the turn-around: when those who have been subjects of description take the opportunity to represent themselves. After a brief history of visual anthropology, we will concentrate on modes of representation developed by indigenous peoples. We will explore the meanings of "indigenous," in connection with various modes of representation, including film, dramatic performances, art, the Internet, and social media. During the semester, we will compare—across time and space—the purposes for which media are used, the transmission of cultural values in media, the organization of production, and the intended audience. Anthropological method and theory will guide our inquiries. Course materials include disciplinary readings, documents dealing with indigenous rights, and examples of the work of indigenous peoples.

79-279 Comparative Study of Nationalism Case Studies: USA, Arabia, South Africa

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. This course, dealing with a significant historical question of the past century, will enable students to develop a deeper understanding of the origins of many contemporary states as well as problems in former colonies. Participants will work individually or in teams on research papers pertaining to their chosen countries.

79-281 Introduction to Religion

Intermittent: 9 units

This course introduces students to methods of inquiry used in the academic study of religion and some of its key concepts, such as "the sacred," ritual and myth. Students learn how scholars study religion in the fields of history, anthropology, sociology, psychology, philosophy and literary criticism. Throughout the course, students examine the questions "What is religion?" and "How can I best study religion?" in order to prepare themselves to pursue a Religious Studies Minor or to further their own study of religion in any discipline.

79-282 Europe and the World since 1800

Intermittent: 9 units

This course will introduce students to topics of historical and contemporary relevance in European society and culture from the nineteenth-century to the present. The course will focus on issues of national and cultural identity with special attention to the situation of inhabitants who have been considered outsiders or "others." We shall examine Europe's place in shaping debates—both new and old—about topics such as: religious, ethnic, and national identity; immigration to and within Europe; Islamophobia; antisemitism, and marginalization of the Roma. Throughout the course we shall also consider the shifting meanings that have been assigned to the concept of Europe as well as how these meanings have been contested. In addition to class lectures, students will become familiar with these themes through the reading and discussion of historical and anthropological texts, current political and cultural debates, music and film.

79-285 Islam in the United States

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. As is well known, America has become a land of great religious diversity, and Islam in particular. Appreciating this issue helps appreciate the dynamism of the US and the religion of Islam. To a degree, however, this is both an old and new phenomenon. The course will explore the many facets of Islamic history and life, the process of its growth as well as the challenges and issues that American Muslims of different colours and backgrounds face in a vibrant plural democratic society.

79-288 Bananas, Baseball, and Borders: Latin America and the United States

Intermittent: 9 units

This course examines the tumultuous and paradoxical relationship between Latin America and the United States from the early 1800s to the present, with an emphasis on Central America and the Caribbean during the Cold War era (1945-1989) and its aftermath (1989-2014). During the Cold War years, the United States intervened frequently in Latin America; following the Cold War, a new geopolitics emerged shaped by trade policies, immigration, and illicit drug trades. We will study relationships between U.S. and Latin American governments, but we will also consider many other kinds of people and institutions including artists, athletes, businessmen, coffee farmers, consumers, corporations, Hollywood studios, journalists, migrant workers, musicians, rebels, scientists, and tourists. We will learn about these people via readings, historical documents, film, music, and video.

79-289 Animal Planet: An Environmental History of People and Animals

Intermittent: 6 units

Why do modern societies go to great lengths to protect some animals and slaughter others? How do people use animals to demarcate boundaries among themselves and between "humans" and "nature?" What are the environmental ramifications of domestication? What role do animals play in visual culture? These are some of the questions that we will seek to answer as we explore the role of human—animal relationships in making the modern world (ca. 1400-present). We will pay particular attention to visual representations of animals across time and cultures. Evaluation will be based on active participation in class discussions, submission of weekly field notes, and a final assignment focused on visual representations of people and animals.

79-291 Globalization in East African History

Intermittent: 6 units

Most Americans would identify slavery and colonialism when thinking of Africa's relationship to the rest of the world. While these two institutions have been critically important in shaping Africa's present condition and recent history, they only constitute a fraction of Africa's past and its interaction with the wider world. This course traces globalization to ancient times and seeks to understand it from an African perspective.

79-293 Inward Odyssey

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. Inward Odyssey will explore world history by examining it through the outward-looking eyes of travel writers, on the assumption that travelogues, though supposedly written about the "other," in fact provide crucial insights about the mindset of the culture that produced them, and often serve as a vehicle for cultural self-exploration or even self-criticism. In terms of content, this course is intended to overlap with World History, Islam and the European World, and US-Arab Encounters. However, this course is intended to be a skills course, designed not to teach students about specific historical periods, but rather to give students the tools they need to conduct their own critical explorations into the historical past.

79-294 Islam on the Main Street in the West since the 18th Century

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. This introductory course to the humanities and social sciences through the prism of religion and faith, aims at: 1. analyzing the interaction between these central disciplines and at appreciating the significance of Western and Islamic humanism and applying it to the present context of cultural globalism, confrontation and dialogue; 2. becoming familiar with some important literary texts of the modern era; 3. learning how to articulate one's thoughts in a cogent manner. The discussion will stress how religion, a powerful instrument of socialization may, under some circumstances, foster intolerance and inequality or openmindedness and tolerance. Understanding this process may lead to a new appreciation of classical Western writings.

79-295 Race Relations in the Atlantic World

Intermittent: 9 units

This course is an analysis of the dynamics of race relations in the Atlantic world through the intersections of race, gender and social class. We will explore the socio-historical and present interactions of "the races" and the construction of racial identity in a variety of circumstances and cultures. We will also use film, music, literature, and concrete examples from world events to examine the asymmetrical power relations that have developed between populations living in close proximity. An important aspect of the course will be the deconstruction of whiteness, blackness, otherness, and the norm in the context of group interaction and the distribution of power. The focus of this class will be on specific examples from North America, the Caribbean, and Latin America.

79-296 Perspectives on Social Protest

Intermittent: 9 units

Social protest, when people come together to contest official policies or demand change, is a significant source of social transformation. From intense moments of popular uprising, like the 1999 Seattle protests against the WTO meetings or the water wars in Bolivia, to the continuous and extended efforts of organized social movements like the Mothers of the Plaza de Mayo, the unified efforts of individuals working together carry limitless possibilities for drawing public attention and affecting the world in which we live. In this course, we will look at instances of social protest, investigating the forms it takes and the ways in which specific cultural and local histories are reflected and utilized in these spontaneous and organized expressions of collective will. Through readings and film we will pay attention to issues of organization and spontaneity, violence, and the use and definition of public spaces. Using case studies from across the world, with a particular focus on Latin America but also including Northern Ireland, Algeria, India, the United States, and Japan, we will consider how cultural forms can be taken and worked into powerful and sometimes dangerous techniques of resistance. We will examine as well the challenges that groups face when they reach beyond their local cultural histories to make national and transnational connections with other groups.

79-297 Dilemmas and Controversies in Anthropology

Intermittent: 9 units

Anthropology is poised at the intersection of art and science. Like scientists, anthropologists collect and analyze data, but it is data gained through relationships forged with and by human beings situated in complex historical, social, political, and economic contexts. In this course, we will investigate the particular approach anthropologists take to research, focusing on the methods that anthropologists use, and the various ethical and technical dilemmas that they face. Though focused on anthropology, the subject matter of this course is relevant for thinking through the moral and practical implications of research more generally. We explore some key controversies that have arisen around anthropological research, and students are encouraged to think deeply and analytically about the particular kinds of knowledge that research generates and to reflect critically on anthropology's strengths and limitations. Note: This is a discussion-based course, where your success is contingent upon thoughtful and active participation.

79-298 Mobile Phones & Social Media in Development & Human Rights: A Critical Appraisal

Intermittent: 6 units

This course will examine the ways that social media and the ubiquity of mobile phones with good cameras and Internet access are changing how information about development and human rights is gathered, analyzed, and disseminated. We will ask: What are the new possibilities opened up by these technologies? What are the potential pitfalls—e.g., privacy concerns, risks to sources, or the false confidence that we are now able to know everything about what is happening in the world? What are the biggest technical, cultural, and political challenges in this domain? Who is responding to these challenges and what are they doing? And perhaps most importantly, to what extent can advances in technology ameliorate problems that are fundamentally political in nature?

79-299 Trafficking Persons: Children in a Global Context

Intermittent: 9 units

Many items circulate around the world, including persons. This course will examine the movement of children from one place to another. From child soldiers to sex workers, from adoptees to laborers, children form part of a global circulation that has complex personal, practical, and political consequences. We will take an anthropological and a historical perspective, comparing the various ways in which children circulate, the changes over time, and the impact of scholarly writings, legal systems, and human rights policies on these movements. We will analyze the role of nation-states, international organizations, and NGO's, along with the decisions individuals make about the well being of a child. Course material includes: anthropological studies, historical accounts, memoirs, and film.

79-300 History of American Public Policy

Intermittent: 9 units

This course will describe and analyze aspects of the development of public policy in the United States from the colonial era to the present, with a focus on the post-Civil War era. For the purposes of this course, public policy will be defined as the making of rules and laws and their implementation by government: 1) in response to the failure of private actors (i.e., markets) to reach desirable outcomes; 2) to regulate markets to influence their outcomes; or 3) in an attempt to achieve a particular normative vision of what society ought to be like. This course assumes that the public policy landscape is complex but still comprehensible given the proper set of analytical frameworks and appropriate historical background. Particular emphasis will be placed on: changing views about the authority of the government to intervene in economic and social issues; the best way to balance individual and collective interests; and the variability within society of the life courses of individuals. Topics to be covered include: immigration, health care and health insurance, and domestic surveillance.

79-301 History of Surveillance: From the Plantation to Edward Snowden

Intermittent: 6 units

Edward Snowden's revelations about the extent of the U.S. National Security Agency's data collection infrastructure have made surveillance one of the most controversial political issues of our time. In this course, we will place the NSA's actions in context, examining the long history of surveillance in the United States. We will begin with the 18th-century plantation "overseer," who was charged with ensuring the productivity and obedience of slaves under his watch. We will then move on to explore the emergence of commercial surveillance in the 19th century, which sought to gather intelligence on the credit worthiness and moral worthiness of businessmen in a rapidly growing, and increasingly impersonal, economy. Next, we will examine the shifting focus of surveillance from the late 19th century to the present, as it expanded from immigrants and criminals to include industrial workers, political radicals, civil rights activists (most notably Martin Luther King), the poor, and ultimately, all of us. Today, anyone who has a cell phone in their pocket, surfs the Internet, keeps up with friends through social networks, makes purchases with a credit card, uses membership cards, travels, or even just spends time in public spaces ought to assume that their movements, purchasing habits, communication metadata, social connections, and Internet browsing histories are being recorded, stored and analyzed for a variety of governmental and commercial purposes. In the final week of the course, we will debate the implications of these incursions into our public and private lives.

79-302 Drone Warfare: Ethics, Law, Politics, History, and Strategy

Intermittent: 6 units

Unmanned aerial vehicles (commonly referred to as drones) have become a central feature of the United States' global counterterrorism strategy since September 11, 2001. According to proponents, drones are much safer than manned aircraft (because there is no pilot to be injured or killed), so accurate that they can be used to target individuals and small clusters of suspicious people in non-battlefield environments, and efficient and inexpensive enough to be used for long-term surveillance missions around the globe. According to critics, the use of drones by military and intelligence agencies is often unethical, that it is illegal to target individuals or small groups of people outside of formally declared war, and that there are hidden costs to drone warfare that are underreported in the mainstream media (including high civilian casualties, the intense psychosocial trauma inflicted upon communities that experience drone strikes, and the psychological impact on drone operators who witness the damage they cause through a computer monitor thousands of miles away). This course will evaluate these issues through the lenses of law, ethics, politics, history, and military strategy.

79-303 Pittsburgh and the Transformation of Modern Urban America

Intermittent: 6 units

This course will focus on the transformations, both negative and positive, of the city of Pittsburgh and of the Pittsburgh region in the period from 1945 through the present. It will explore the following themes: the redevelopment of the city in the Pittsburgh Renaissance (I & II), the collapse of the steel industry and the development of a service economy, the city's changing demography, suburban development, neighborhood decline and renewal, and environmental policy and change.

79-304 African Americans in Pittsburgh

Intermittent: 6 units

This course will examine the development of Pittsburgh's African American community from the Great Depression and World War II through the era of deindustrialization during the late 20th and early 21st centuries. The course will emphasize not only the ways that a variety of external socioeconomic, cultural, and political forces shaped the history of black people in western Pennsylvania, but also the diverse strategies that African Americans devised to give meaning to their own lives and how these changed over time. Students will read both primary and secondary accounts of Pittsburgh's African American history; write short analytical papers on specific topics or themes; and engage in regular classroom discussions of assigned readings.

79-305 Moneyball Nation: Data in American Life

Intermittent: 9 units

From conducting clinical trials and evaluating prisoners parole cases to drafting professional ballplayers, we increasingly make decisions using mathematical concepts and models. This course surveys the development of-and resistance to-such tools by grounding them in the recent cultural history of the United States. Focusing on baseball, medicine, and the law, we'll explore how and why Americans have come to believe mathematical and computational methods can solve complicated problems, even in seemingly unrelated moral, political, and social domains. The course encourages students to think critically about the wider implications of these transformations by situating their development historically.

79-307 Religion and Politics in the Middle East

Intermittent: 9 units

This course looks at the historic relationship among Islam, Judaism and Christianity and what they have to say about the nature of government, the state's treatment of religious minorities, and relations among states in the Middle East. We will consider the impact of religion on domestic and foreign policy in selected Middle Eastern countries and communities, the role of religion in fueling conflicts, the phenomenon of religious fundamentalism, the challenge and opportunity this presents to the United States, and the potential for religion to help advance Middle East peace. We will take advantage of the unprecedented upheavals roiling the Arab world since 2011 and use contemporary social media to contact people on the ground in the states we are studying to produce "updates" as to where religion and politics seem to be intersecting at this time.

79-308 Inventing the American Airplane: Technology and Military Aviation, 1898-1945

Intermittent: 6 units

This course explores one of the great technological inventions of the first half of the 20th century, the airplane. Beginning in 1898 with the Army's support of Samuel Langley, whose efforts to invent the airplane ultimately failed, the course focuses on the key role played by the military in shaping the airplane's evolving design, manufacture, and multiple uses. As we will see, while the Wright brothers successfully invented the airplane, they gave little attention to how it might be used. In negotiating with the US Army in 1907 to sell their plane to the government, the brothers suggested merely that it would be useful in reconnaissance. By the end of World War II, however, the airplane had fundamentally changed the nature of modern warfare, with the US military using airplanes in a much wider variety of roles: offensive, defensive, and support. This course will track these changes and place them in historical context. It will weave together themes from the history of technology, the history of the military, and American social and political history to explore the airplane's use, especially in a military context, between 1898 and 1945.

79-309 20th Century China Through Film

Intermittent: 9 units

This course is about both film and history. It is not a detailed history of film, but rather introduces some issues of modern Chinese history and examines how that history is treated in film, mostly Chinese film, of the past twenty years. We have selected some well-made films exploring some key issues of 20th century history, including several of Zhang Yimou's works, documentaries made in the U.S. with Chinese assistance, and works by leading Taiwanese and Chinese American directors. In a few cases themes will be illustrated in excerpts. The readings consist of topical articles and book chapters, tied together by a general history of the period. The twice-a-week evening sessions are alternately for film viewing and discussions. Frequent short assignments, some of them collaborative, will explore the social context and methodology of the films, developing critical skills in writing, observation, film, and historical imagination.

79-310 From Al Qaeda to ISIS: U.S. and European Anti-Terrorism Policies, 9/11-Present

Intermittent: 9 units

The brutal regime that ISIS has established in parts of Syria and Iraq, and the recent terrorist attacks in Paris and Copenhagen, have reminded Americans and Europeans of an almost forgotten war: the "global war on terror" that President George W. Bush declared after September 11, 2001. However, the perception of the threats that ISIS poses to Western societies differs from the perceptions post-9/11, as do the policies the US and European governments have chosen. The frameworks of US and European policies towards "Islamist terrorism" have been shaped primarily by the way governments and citizens experience, interpret, and assess the long "global war on terror." In this course, we will review the origins of the "global war on terror" that started in the aftermath of 9/11, unfolded in Afghanistan and Iraq, played out in a secretive war "on the dark side," and resulted in today's global surveillance effort by the US. Analysis of current policy debates on the GWOT will conclude the course.

79-312 International Human Rights Institutions in Theory and Practice

Intermittent: 6 units

What role do international human rights institutions play in the protection and promotion of human rights? How and when did they emerge? To what extent are they (or could they be) effective? This mini course considers the historical development of the contemporary idea of human rights, the theoretical and ethical debates that accompanied the creation of international bodies designed to regulate and enforce them, and the promises and limitations embedded in the forms these have taken. It considers ethical, legal, moral, and political dilemmas that arise over the nature of such institutions and around the concept of rights they uphold. Finally, the course considers the effectiveness of these bodies in serving as vehicles or facilitators of forms of justice and in promoting the construction of just and peaceful societies.

79-314 The Politics and Culture of Memory

Intermittent: 9 units

What is the relationship between an individual person and collective memories? How do societies "remember"? Could in fact an individual form a memory isolated from any social and cultural framework? What is the relationship between remembering and the writing of history? This course proposes an interdisciplinary approach to the relationship between memory and history, as it is reflected by the cultural and historical analyses of 20th century Europe, as well as by broader historiographical and conceptual debates at a global scale. The first part will first address some of the most important theoretical concerns about the relationship between memory-making and history-writing. The second part of the course will focus on the relationship between history and memory in 20th century Europe. We will approach the relationship between history and memory by exploring how memory itself began to matter in 20th century Europe; how different groups have started to mobilize their remembrances of the past for political and economic ends; and how individual testimonies, as innovative forms of expression, have challenged history writing as a genre, as well as made conceptually powerful topics such as the body, experience, trauma, and nostalgia.

79-315 Hawai'i: America's Pacific Island State

Intermittent: 9 units

The course focuses on Hawai'i—a Pacific Island, an American state, and a popular tourist spot. Hawai'i at once fills our imagination and occupies a strategic niche in United States policies. The story has not always been positive: we will take a historical perspective on the changes in Hawai'i over the past two and a half centuries, and we will explore the culture of the islands. We will read accounts by "outsiders" and accounts by kama'ainana, "children of the land," residents of Hawai'i. We will also consider representations of the islands in media other than text, films, for instance, and visual arts. The goal is to explore the complexity of a place that is often stereotyped as "paradise," but exemplifies problems of conquest and commercialization, of ethnic groups and boundaries, of commercialization and globalization, and of identity politics and independence movements. Readings include anthropological texts, literature, and selected essays.

79-316 Photography, the First 100 Years, 1839-1939

Intermittent: 9 units

Photography was announced to the world almost simultaneously in 1839, first in France and then a few months later in England. Accurate "likenesses" of people were available to the masses, and soon reproducible images of faraway places were intriguing to all. This course will explore the earliest image-makers Daguerre and Fox Talbot, the Civil War photographs organized by Mathew Brady, the introduction in 1888 of the Kodak by George Eastman, the critically important social documentary photography of Jacob Riis and his successor, Lewis Hine, the Photo-Secession of Alfred Stieglitz, the Harlem Renaissance of James VanDerZee, the precisionist f64 photographers Ansel Adams, Imogen Cunningham, and Edward Weston, and other important photographers who came before World War II. The class will be introduced to 19th century processes, such as the daguerreotype, tintype, and ambrotype, as well as albumen prints, cyanotypes, and more.

79-317 Art, Anthropology, and Empire

Intermittent: 9 units

This seminar will explore the anthropology and history of aesthetic objects, as they travel from places considered "primitive" or "exotic," to others deemed "civilized" or "Western." First, we will consider twentieth-century anthropological attempts to develop ways of appreciating and understanding objects from other cultures, and in the process to reconsider the meaning of such terms as "art" and "aesthetics." Then we will discuss several topics in the history of empire and the "exotic" arts, including: the conquest, colonization and appropriation of indigenous objects; the politics of display and the rise of museums and world fairs; the processes by which locally-produced art objects are transformed into commodities traded in international art markets; the effects of "exotic" art on such aesthetic movements as surrealism, etc.; and the appropriation of indigenous aesthetic styles by "Western" artists. Finally, we will consider attempts by formerly colonized populations to reclaim objects from museums, and to organize new museums, aesthetic styles, and forms of artistic production that challenge imperialism's persistent legacies.

79-318 Sustainable Social Change: History and Practice

Intermittent: 6 units

If you wanted to change the world, who would you ask for guidance? Mahatma Gandhi, Martin Luther King, Mother Theresa, Rachel Carson, or Nelson Mandela? In this interdisciplinary course, we will examine the history of efforts to create sustainable social change. Through a series of targeted case studies, we will examine the successes and failures of notable leaders, past and present, who strove to address social problems nonviolently and to create lasting improvements in fields such as education, healthcare, and human rights. In keeping with the example of the people we will be studying, we will bring our questions and our findings out of the classroom through a variety of creative, student-driven experiments in sustainable social change.

79-319 India through Film

Intermittent: 6 units

Bollywood films attract hundreds of millions of viewers, not just in India but throughout the world. The name "Bollywood" makes it seem that the Indian film industry is a junior partner, merely an echo of Hollywood. But more films are made in Mumbai every year than in Los Angeles. And Mumbai is only one of many film hubs in India. The rich diversity of Indian cinema speaks to the equally rich history of India itself. This course uses Indian movies to examine several key themes in India's history. We will focus on the twentieth century and on questions of democracy, diversity, and development. This course includes a mandatory film screening on Wednesday evenings beginning at 6:30pm.

79-320 Women, Politics, and Protest

Intermittent: 9 units

This course examines the history of women's rights agitation in the United States from the early nineteenth-century to the present. It investigates both well-known struggles for women's equality—including the battles for women's voting rights, an Equal Rights Amendment, and access to birth control—and also explores the history of lesser-known struggles for economic and racial justice. Because women often differed about what the most important issues facing their sex were, this course explores not only the issues that have united women, but also those that have divided them.

79-323 Family, Gender, and Sexuality in European History, 500-1800

Intermittent: 9 units

The medieval and early modern periods witnessed a transformation in the cultural and social understandings of gender. During this period, the mutable sexual categories of the pre-modern world evolved into the definitions of masculinity and femininity recognizable today. This course examines these changes in the understanding of gender and the family in Europe in the medieval and early modern periods, drawing upon readings in gender history, marriage and the family, and the history of sexuality. We will explore the ideal of Christian marriage and family and examine how the "ideal" compared to the reality on such issues as marriage practices, family, gender roles, and sexuality. We will also explore the fashioning of female and masculine gender norms and the construction of the male and female sense of self over time. In the process, we will examine the larger historiographical issue of the use of gender as a tool of historical analysis.

79-324 Adolescence in the 20th and 21st Centuries

Intermittent: 6 units

This mini-course examines the changing pathways to adulthood over the past century, with particular focus on schooling, attitudinal and behavioral expectations for adolescents, and demographic patterns (fertility, family formation and dissolution, and mortality). Readings will be multi-disciplinary, including the perspectives of historians, sociologists, demographers, developmental psychologists, economists, and reports of state and international organizations. This is very much a discussion class, and you need to come to class prepared to wrestle together with our readings and our evolving understanding of the history of the paths to adulthood.

79-325 U.S. Gay and Lesbian History

Intermittent: 6 units

US Gay and Lesbian History offers an overview of the changing context and circumstances of sexual minorities in American culture. From early constructions of moral opprobrium, criminal deviance or medical pathology, the LGBT community emerged in the twentieth and twenty-first century as a political constituency and a vital part of contemporary society. Students should be aware that this course will necessarily address issues of intimate relations and sexuality as well as broader historical issues.

79-326 German History through Film

Intermittent: 9 units

This course offers both a history of German cinema and a survey of 20th-century Germany as seen through German films. As film history, the course introduces students to movies spanning the silent era, Nazi films, the West German New Wave, socialist cinema, and post-unification movies. We will consider stylistic and technical trends as well as dramatic content. As a course in German history, the course sets major movies from each era against a backdrop of political, social, and cultural developments. We will also analyze the portrayal of World War II and the Third Reich in films made after 1945. We will view approximately 18 films, mostly in class but several outside of class. Readings will include works on the history of German film and a textbook on 20th-century German history. Writing will consist of three 5-page essays and one 8-10 page paper.

79-328 Photographers and Photography Since World War II

Intermittent: 9 units

Invented in 1839, photography was a form of visual expression that immediately attracted a large public following. Starting around 1900, photography was practiced with two dominant strands. One of these firmly believed in the power of photographs to provide a window on the world, and was led by Lewis Hine, whose documentary photographs for the National Child Labor Committee helped to ameliorate living and working conditions for thousands of immigrant children. The other strand adhered to the philosophy of Alfred Stieglitz who adamantly affirmed that photographs were first and foremost reflections of the soul and were art objects, equal to painting, drawing and sculpture. These two schools of thought guided photographers throughout the twentieth century. This course explores in depth the tremendous range of photographic expression since World War II and examines in particular the contributions of significant image-makers such as Helen Levitt, W. Eugene Smith, Robert Frank, Diane Arbus, Garry Winogrand, Charles "Teenie" Harris, Cindy Sherman, Carrie Mae Weems, Nan Goldin, James Nachtwey, and many others. Classes include a slide lecture, student presentation, and video segments that introduce a focused selection of images by major photographers in an attempt to understand their intentions, styles, and influences. In Spring 2015, students will be expected to make one or more visits to Carnegie Museum of Art to view Storyteller: The Photographs of Duane Michals, an internationally recognized living photographer who is being celebrated this year with this retrospective exhibition.

79-330 Medicine and Society

Intermittent: 9 units

This course examines the history of American medicine, public health, medical research and education, disease patterns, and patients' experiences of illness from the colonial period to the present. Students read the voices of historical actors, including physicians, patients, policy makers, and researchers. In analyzing these voices, students will learn what was at stake for different sets of actors as they confronted diseases and struggled to explain and cure them.

79-331 Body Politics: Women and Health in America

Intermittent: 9 units

Women's bodies have been the sites of long-standing, and sometimes deadly, political battles. This course takes a topical approach to the history of American women's health in the nineteenth and twentieth centuries in order to understand why women's bodies have been such heated sites of struggle. It covers topics such as the history of contraception, abortion, menstruation, sexuality, female anatomy, rape, domestic abuse, menopause, pregnancy, and childbirth. It explores how American culture has constructed these issues over time, while also examining women's organizing around them. This course is open to all students.

79-332 Medical Anthropology

Intermittent: 9 units

This course will explore the ways in which different cultures conceptualize the body and its relation to the physical, social, and supernatural environments. We will examine how illness and its causes are understood, investigating not only the beliefs and practices surrounding healing, but also the social position and training of the healers themselves. In order to understand the context of healing in cross-cultural perspective, we will problematize the boundaries between medicine and other arenas of social life: religion, politics, law, economics, etc. We will investigate issues of medical efficacy (what "works"?) by asking who or what is being healed in different kinds of medical practices, and we will consider the ways in which power and social control are exerted through medical discourses of various sorts. Finally, we will examine the history of medical anthropology from its "clinical" origins in international development, through anthropological critiques of clinical perspectives, to attempts to fuse clinical and critical approaches. Throughout the course, Western medical practice will be analyzed as one of many forms of ethnomedicine and ethnopsychology.

79-338 History of Education in America

Intermittent: 9 units

Americans have long understood schools both as mechanisms for inculcating communal values and as instruments for social reform. Schools have been alternatively described as pillars of democratic society and as authoritarian institutions for managing deviance. Institutions of education—whether schools, colleges, or universities—figure prominently in discussions of inequality and discrimination, opportunity and meritocracy. This course provides an introductory historical survey of American educational ideas and institutions. From debates in the 17th and 18th centuries over the proper balance of religious and secular education to fierce battles today over the role of the federal government in enforcing No Child Left Behind, citizens have been politically mobilized through their concerns about education. By understanding the complicated history of American educational ideas and institutions, this course prepares students to engage critically with ongoing debates about vouchers, charter schools, national standards, and curriculum controversies.

79-339 Juvenile Delinquency and Film (1920 to "The Wire")

Intermittent: 9 units

How have American films portrayed juvenile delinquency and the juvenile justice system? What does filmmakers' portrayal of juvenile delinquency tell us about American culture and society? Do films vividly capture or badly distort the "realities" of crime and the operations of the justice system? This course uses feature films (to be viewed in advance of class) from the past 100+ years, as well as various sociological, psychological, and historical readings, to explore these issues. The course is run as a colloquium, with students playing central leadership roles in launching and guiding class discussions.

79-340 Juvenile Delinquency and Juvenile Justice

Intermittent: 9 units

This course will track the development of an American institution, the juvenile court, in the context of changing patterns of juvenile delinquency from the early 19th century to the present. We will integrate historical, legal, sociological, and cultural perspectives in tracking the court's evolution, culminating in a careful look at how recent reform movements are playing out nationally. Readings will include a wide variety of secondary and primary historical sources from different time periods. We will also view and discuss several films (including Frederick Wiseman's 1973 classic, "Juvenile Court"). As opportunities develop, we may also hear from current court practitioners as guest lecturers. The course is run as a colloquium, with students playing central leadership roles in launching and guiding class discussions.

79-341 The Cold War in Documents and Film

Intermittent: 9 units

This course is based on use of historical documents and films to study problems that reshaped the world during and after the Cold War. We will examine how documentary and feature films depicted the most important events of the Cold War, such as the Korean War, the construction of the Berlin Wall, the Cuban missile crisis, and others. In addition to films, sources will include documents, lectures and readings.

79-342 Introduction to Science and Technology Studies

Intermittent: 9 units

This course provides an introduction to Science and Technology Studies, a vibrant interdisciplinary field that examines the ways that science and technology interact with contemporary politics, culture, and society. Using theories and methods from history, philosophy, anthropology, and sociology, we will examine the following topics: the nature of scientific and technical knowledge; the formation of new fields of interdisciplinary expertise following the Second World War, specifically the rise and fall of the atomic scientists; the cybernetic approach to humans as "systems;" the emergence of risk societies; systems of classifications and categories and their impact on ideologies of race, sex, and gender; and possibility of objectivity; and the public understanding of science.

79-343 History of American Urban Life

Intermittent: 9 units

This course examines the development of urban America during the 19th and 20th centuries. It explores the evolution of urban structure; the development and impact of urban technologies (transportation, water/wastewater, energy and communications); ethnic and racial change and class conflict in the city; and political and policy issues. It discusses alterations in American city structure and form through the walking city, the networked city, and the development of the suburbs.

79-345 The Roots of Rock and Roll

Intermittent: 9 units

This course is about open source, collaborative innovation and the impact of social and technological change on American music between 1870 and 1970. We will spend the first 8 weeks on early "remix" music (slave songs, Anglo-Appalachian ballads, ragtime, and Depression era blues and country). After studying Bessie Smith, Woody Guthrie, Lead Belly, Hank Williams, and other early artists, we'll spend the last 7 weeks on revolutionaries like Chuck Berry, Bob Dylan, Jimi Hendrix, and Janis Joplin. The format is informal lecture and discussion. Assignments include reading two books plus some articles, weekly music listening, short papers, and a final project.

79-346 American Political Humor

Intermittent: 9 units

This course takes a cultural approach to U.S. history since the Civil War, as seen by the nation's most astute and influential critics: its political humorists. Besides immortals like Mark Twain and contemporary novelist Don DeLillo, we will (re)discover the satirical yet hilarious voices of H.L. Mencken, Will Rogers, Dorothy Parker, Walt "Pogo" Kelly, Richard Pryor, Fran Lebowitz, and others through essays, novels, recordings and films. At its sharpest edges, humor addresses issues of class, gender and race in American life, and provokes alternative thinking about mass culture, consumerism, and conformity. Assignments include short analytical essays and a final paper.

79-348 Abraham Lincoln at 200

Intermittent: 9 units

Following up on the bicentennial of Abraham Lincoln's birth, this course will explore both his historical importance and his changing status as an American icon. We will not only learn about Lincoln's life, we will address controversies about him (such as his attitudes and motives regarding slavery and racism). Readings will include a short biography, a book about his struggles with mental illness, a book about his friendship with Frederick Douglass, and Lincoln's own speeches and writings. His skills as a precise and succinct writer will be an ongoing focus; hence, assignments will emphasize the drafting, revising, and polishing of short essays, rather than the memorization of facts.

79-349 The Holocaust in Historical Perspective

Intermittent: 9 units

This course explores the attitudes and actions of Holocaust perpetrators, victims and bystanders including the responses of the U.S. and its Allies. What did the U.S. do or not do that might have impacted on events overseas? What implications and issues arise from this watershed event in history? We descend into the world of the Holocaust not only by reading from primary and secondary sources and viewing several films, but also by hopefully meeting a Holocaust survivor.

79-350 Early Christianity

Intermittent: 9 units

In this course we examine the origins of Christianity. Although we deal with biblical as well as other contemporary materials, the approach is not theological but historical. We want to understand how and why Christianity assumed the form that it did by examining its background in the Jewish community of Palestine, its place in the classical world, its relationship to other mystery religions of the time and certain variant forms (now known as Gnosticism) which it assumed prior to the crystallization of orthodoxy.

79-352 Christendom Divided: The Protestant and Catholic Reformation, 1450-1650

Intermittent: 9 units

At the dawn of the sixteenth century, western Europeans still shared a common religion and identity as members of the Roman Catholic Church. Within less than two decades, this uniformity began to crumble, and the very fabric of western culture was irrevocably altered. By 1550, Europe was splintered into various conflicting churches, confessions, sects, and factions, each with its own set of truths and its own plan for reforming the church and society at large. This period of rapid and unprecedented change in western history is commonly known as the Reformation. Though this term has traditionally referred to the birth of Protestantism, it also encompasses the simultaneous renewal and reform that occurred within Roman Catholicism. This course will survey the Reformations of the sixteenth century, both Protestant and Catholic, examining the causes of the Reformation, the dynamics of reform, and its significance for western society and culture. In the process, we will analyze such on-going problems as religious persecution and the accommodation of dissent, the relationship between religion and politics, and the interactions between ideology and political, social, and economic factors in the process of historical change.

79-353 Religious Identities and Religious Conflicts in 19th Century Europe

Intermittent: 9 units

This course explores the place of religious identity and conflict in the history of European society from the French Revolution to World War I. We study the many ways that individuals constructed and used their religious identities to approach problems of public life. We examine continuities and changes in religious institutions as well as conflicts between churches and states. The course shows that, far from declining in importance during the processes of economic and political modernization, or becoming part of private life, religious beliefs and identities played an increasingly critical role in public life. We approach the topic through case studies, beginning with the religious conflicts and settlement between church and state during the French revolution, Evangelical Christian participation in the anti-slavery movement in Britain, Protestant-Catholic rivalries in Germany, the power of the papacy in Italy, and the Dreyfus case in France. Students will have reading assignments from both primary and secondary sources.

79-354 Energy & Climate: History, Science, Technology, and Policy in the US 1776-2076

Intermittent: 9 units

This course provides CMU students with a historically grounded, technically informed, and policy-centered examination of energy and climate in the United States from the American Revolution to the nation's tri-centennial, by which time the nation will either have taken the necessary action to avoid massive catastrophes related to global warming or will be destined for—and perhaps already experiencing—a series of vastly catastrophic climate events that visit apocalyptic-like suffering and misery on large segments of the nation. Energy procurement and expenditure in the US and climate change have been surprisingly linked over the nation's entire. Now is the time for CMU students to understand these relationships historically, technically and scientifically, and politically and geopolitically. The course is structured around the reading and discussion of landmark scholarship on energy and climate sewn together by lectures, films, and various unorthodox pedagogical methods.

79-355 Who is a Citizen? The Politics and Cultures of Citizenship in Global Perspective

Intermittent: 9 units

What does it mean to say that someone does (or does not) have rights of citizenship? How are ideas of the rights and responsibilities of citizens different in nations across the world? In what ways does the lived practice of being a citizen differ from ideal notion(s)? In this course, we look at the history and development of the idea of citizenship in a cross-cultural perspective, focusing on the global interconnections that influence the forms that citizenship takes. We will examine the roots of political citizenship in Western society, and compare these to other foundational notions of state-subject relationships (such as in the Ancient Near East and Ancient China). We then consider the formation of European nation-states and the emergence of modern citizenships. In the second half of the course, we use examples from across the world to think about how subjects experience citizenship in particular ways, paying special attention to the margins and borders of citizenship (refugees, migrants, internally displaced peoples, cultural minorities, economically disadvantaged communities, etc.). The class is discussion-based, and students will complete short assignments and a final essay.

79-357 History of Black American Music

Intermittent: 6 units

Come and explore the rich musical heritage of Black America. This course will survey the music of Black America beginning with the African legacy and continuing through the music of the Twentieth Century. Class sessions will involve discussions, listening, viewing of films, and reports by students on topics of individual interest. Discussions will involve, historical, cultural and political perspective, as well as the music and composers themselves. Lecturing will be at a minimum. Innovative testing in quiz show format will be used. No prerequisites required. Open to upper level undergraduate students.

79-359 Terrorism and U.S. National Security

Intermittent: 6 units

In 2001, the U.S. government declared a "global war on terror" (GWOT) in response to the terrorist attacks of September 11. What happened to this war? How did this GWOT affect the USA and its national security? After studying the policy choices made in 2001, we will explore the GWOT's impact on the subsequent development of U.S. national security policies. Finally, and most importantly, we will discuss and assess how these policies have affected the security and civil liberties of American citizens.

79-360 Conspiracies, Spies, and Assassins in Revolutionary Europe

Intermittent: 6 units

This course focuses on several conspiracies that dominated European thinking in the late 18th and early 19th centuries (roughly, 1790-1820.) Fueled by the French Revolutionary and Napoleonic Wars, many Europeans saw conspiracies behind every door and spies in every corner. Some of these conspiracies and spies were real, some less so. Using contemporary sources (including newspaper reports, letters, military dispatches and diaries), we will examine the social and political impact of these conspiracies, and the insurgents, spies and assassins who carried out their agendas.

79-362 Law and Disorder in Early Modern Europe, 1400-1800

Intermittent: 9 units

The growth of legal institutions and their expanding use in enforcing "social discipline" marked an important and often controversial development in consolidating the political authority of the emerging states of the early modern era. This seminar will examine this process, looking at early modern European legal institutions and their role in defining and enforcing societal norms of conduct and belief. We will examine how the shifting definitions of "crime" within the period reflected prevailing societal attitudes and anxieties toward perceived acts of deviance and persons on the margins of society. In addition to the workings of governmental and legal institutions, we will also explore the ways in which early modern communities used informal social and economic sanctions to police communal standards, sometimes against the will of the authorities. Assigned readings will address such topics as the early modern European civil, criminal, and ecclesiastical court systems, investigation and punishment of crime, criminalization of social deviance (witches, vagrants, religious minorities and other outcasts), and the legal enforcement of sexual morality and gender roles.

79-363 The Rise of Modern Golf, 1860 to the Present

Intermittent: 9 units

Aristocratic pastime or the people's game? This course will examine the historical emergence of golf as both an amateur and professional sport and as a popular leisure activity between 1860 — when Prestwick Golf Club in Scotland hosted the first (British) Open — and the present day. We will read and discuss a wide variety of historical, sociological, literary, legal, and mass media sources, all designed to illuminate broader themes in social, cultural, political, and economic history. All students are welcome to take the course, whether or not you play the game of golf. However, if you think that St. Andrews is the Vatican's summer home, or that a mashie niblick is a side dish at KFC, you may want to reconsider.

79-369 Disasters in American History: Floods and Hurricanes

Intermittent: 6 units

In this course we will investigate the historical roles played by people in creating the conditions for disastrous floods and hurricanes in the United States, examining the material causes of "natural disasters" and analyzing how Americans have been affected differently according to race and class. By the end of the course, we will have examined some of America's largest flood and hurricane disasters in their historical contexts, and we will use this knowledge to think about disasters that Americans face now and in the future.

79-370 Disasters in American History (2): Epidemics & Fires

Intermittent: 6 units

This course investigates the historical roles played by people in creating the conditions for disastrous outbreaks of disease and fire in the United States, examining the material causes of "natural disasters" and analyzing how Americans have been affected differently according to race and class. By the end of the course, we will have examined some of America's largest epidemics and wildfires in their historical contexts, and we will use this knowledge to think about disasters that Americans face now and in the future.

79-371 African American Urban History

Intermittent: 9 units

This course will explore selected themes in the development of African American urban history from its colonial beginnings through the era of Barack Obama during the early 21st century. While giving primary attention to the growth of black urban communities on the ground in major U.S. cities, the course will open and close on a global note. Students will learn that the dominant impact of the English-speaking world on black urban life was not a foregone conclusion. Spanish, Dutch, French, and Indigenous people also shaped the black urban experience in North America. In addition to weekly classroom discussions of assigned readings, students will select a key theme in the development of African American urban life and, based upon a mix of secondary and primary accounts, write their own original essay on the subject.

79-372 Perspectives on the Urban Environment

Intermittent: 9 units

This course will explore the interaction of cities, technology and the natural environment over time. In doing so it will consider major issues confronting cities today including landscape and site changes; water supply, wastewater disposal and flooding; solid waste disposal; transportation and suburbanization; energy changes; and the impact of deindustrialization. These themes will be approached through a combination of class discussions, lectures, and visiting speakers. Class participation is expected, and will comprise a portion of the grade. In addition to required texts, readings will be distributed on Blackboard.

79-374 American Environmental History: Critical Issues

Intermittent: 9 units

This course explores critical issues in the history of the American environment during the last three centuries. Among the specific topics to be covered are changing attitudes toward nature; forms of rural and urban development and environmental effects; the impacts of technology and industrialism; the conservation and environmental movements; and environmental problems and prospects today.

79-376 Doing Transnational History

Intermittent: 9 units

This course has two broad learning objectives: introduce students to transnational and comparative perspectives on history; and provide students with experiences interpreting primary sources (i.e., historical documents). The specific subject matter will vary from one semester to the next depending on the course instructor's expertise and interests. Potential topics include imperialism and empire; capitalism and commodity flows; labor and human migrations; warfare and genocide; medicine and health; or technology and environment. This course, open to all students, partially fulfills the Theoretical and Topical Core course requirement for Global Studies majors.

79-377 Food, Culture, and Power: A History of Eating

Intermittent: 9 units

This course explores the globalization of food production and consumption in the modern world. We will begin in the present, looking at what specific families around the world eat and situating those meals in cultural, ecological, and historical contexts. We will also consider how powerful political actors like governments and corporations influence what we eat. Then, we will delve into the historical roots and cultural meanings of contemporary foodways. The second half of the semester will focus on individual student research projects focused on transnational dimensions of food. Because food is sensual, we will use images, music, video, and real food in addition to readings.

79-378 Islam and the Integration of Society

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. This is an introduction through the prism of history, religion, sociology and political science, to the general history of Islam since its rise in 7th-century Arabia as well as to the experiences of various Muslim groups in the world. Based on a paradigm borrowed from sociology and politics, it stresses the process of assembling together disparate components to produce a relatively unified entity at the end, thanks to the effects of strong bonds among the members of the community and thanks to the role of divinely inspired —charismatic — leadership. The course will study this multi-faceted process in different geographical and temporal context, thereby teaching students how to think globally and methodically.

79-380 Ethnographic Methods

Intermittent: 9 units

In this class, students will become familiar with the history, the use, and the problems attached to "ethnographic methods." Drawing on diverse anthropological writings, students learn to assess various methods, including observation, participation, interviewing, conversing, mapping, and documenting in visual media in order to create a "thick description" or ethnography. In addition to reading carefully and critically discussing assigned materials, the primary work in the class involves a fieldwork project: each student is expected to develop a project that can be completed in one semester, that involves an application of one or more strategy of inquiry, and that can be written up in a final, interpretive and descriptive paper or presented in visual form, accompanied by a written commentary. There are no exams in the course.

79-381 Energy and Empire: How Fossil Fuels Changed the World

Intermittent: 9 units

Few things have changed the world as much as petroleum: cars, airplanes, fertilizers, plastics are just some of the technologies derived from oil. Moreover, the wealth and power associated with "black gold" has shaped geopolitics in the twentieth century, giving rise to so-called "petro-states." For the first five weeks, we will trace the evolution and expansion of "petrocultures" around the world. The remainder of the course will be organized around individual student research projects. The major learning objective of this course is to give students experience writing an original research paper. Students will be expected to define a research question, assemble a bibliography of sources, write and revise an analytical paper, and do an oral presentation. This course, open to all students, partially fulfills the Theoretical and Topical Core course requirement for Global Studies majors.

79-383 Epidemics, Disease, and Public Health

Intermittent: 9 units

Epidemics of infectious disease are both biological and social events. Through the perspectives of the changing ecology of disease and social construction of disease, this course examines epidemics of such diseases as bubonic plague, cholera, yellow fever, and AIDS. Besides considering the social factors that help determine the epidemiology of a particular outbreak of disease, the course analyzes human responses to epidemic disease. These responses include popular attitudes toward the disease and those who contract it, as well as public health measures intended to control spread of the disease.

79-384 Garbage Gone Global: Managing Waste in an Age of Mass Consumption

Intermittent: 9 units

In this course, we will use readings and film to explore a variety of issues related to the production, classification, and management of waste. Topics to be covered include the environmental impacts of different waste disposal techniques, the global trade in used and discarded materials, garbage as a source of work and the way gender influences who does this work, the history and current structure of the waste disposal industry in the US and in other places around the world, and practices of recycling and scavenging. Throughout we will pay attention to the different ways we as humans think about, care for, and ultimately discard our material things. Class time will be dedicated to discussion, and students will complete weekly short assignments and a research paper.

79-385 The Making of the African Diaspora

Intermittent: 9 units

The trans-Atlantic slave trade dispersed Africans in the New World and the Old, creating the African Diaspora. Generations of scholars have disputed whether descendants of enslaved Africans could have retained any of their African culture and/ or fully assimilated into New World societies. This course will combine a chronological, geographical, and a thematic approach to the creation of new Africa-inspired cultures in both Africa and the African Diaspora. It will explore societies in the Caribbean, the US South, Latin America, and Africa and address themes, such as Africanisms, African survivals, African retentions, Creole languages, and religion.

79-386 Entrepreneurs in Africa, Past, Present and Future

Intermittent: 9 units

Fifty years after Ghana, the first sub-Saharan African nation, gained its independence from colonial rule, African economies continue to rest on a fragile foundation. Entrepreneurs must play an important role in developing the African continent, because both African governments and foreign aid have overall failed. In the face of these myriad of internal and external constraints on economic development, the history of entrepreneurship and future potential for entrepreneurship is often overlooked. This course will show that sub-Saharan Africa is-and has been for centuries-a thriving place of business, despite the obstacles of war, political and economic instability, disease, and famine. It will also focus on the challenges, such as local, regional, and national integration, access to credit and capital accumulation, and debt burden that African economies faced in the past, present, and future. Lastly, it will focus on the strategies that entrepreneurs in Africa-local and foreign-have developed to circumnavigate these challenges-and the opportunities that they have created in spite of them. By taking a historical approach to the subjects of entrepreneurship, innovation, and technology in Africa, this course will define African entrepreneurship in a way that is rooted in Africans' historical experiences and use this definition to put Africa's current and future roles in the global economy into historical perspective.

79-389 Stalin and Stalinism

Intermittent: 9 units

Joseph Stalin has been vilified and praised, damned and worshipped. He left behind a mixed and complex legacy. He created an industrialized modern economy in the Soviet Union and won a great and painful victory over the Nazis. At the same time, he built a police state, sent millions to labor camps, and destroyed the possibilities for socialist democracy. When he died, thousands of Soviet citizens wept at his funeral. This course will combine elements of biography and social history to examine Stalin, the man, and Stalinism, the phenomenon. Using history and film, we will explore one of the most complicated and influential dictatorships of the 20th century.

79-392 History of Modern Warfare

Intermittent: 9 units

This course examines the role of warfare in western society and history during the period of emergence and expansion of western nation states. Central themes include the relationship of war to the political economy of the state, to military technology, and to technological changes in manufacturing. These themes are investigated in the framework of western imperial expansion and the resulting conflicts between competing European empires and the non-European societies in their path. After an introduction to warfare from the classical period through the emergence of modern armies in the 17th century, the course focuses on major global conflicts from the Seven Years War through World War Two. Topics include the gradual evolution of European thinking away from classical ideas about warfare and changing concepts of strategy, tactics, and generalship as a result of industrialization and the emergence of global economic empires.

79-395 The Arts in Pittsburgh

Intermittent: 9 units

This course will examine the arts in Pittsburgh, both historically and in the present. We will focus especially on art exhibits and musical events scheduled by the city's museums and concert halls during the semester. The "curriculum" will derive from the artistic presentations themselves, which will provide a springboard for reading assignments, seminar discussions, and research papers in the history of music and art. We will also examine the historical development of cultural institutions in Pittsburgh. The History Department will pay for students' admission to all museums and studios. However, students will be charged a supplemental fee of a minimum of \$275 to help subsidize the considerable expense of purchasing tickets for concerts and performances by the Pittsburgh Symphony, Pittsburgh Opera, Chamber Music Society, and Renaissance and Baroque Society. Attendance at all art exhibits and musical events is required. Prerequisite: Availability to attend art exhibits on several Fridays and Saturdays, and to attend musical events on several Thursday, Friday and Saturday evenings.

79-396 Music and Society in 19th and 20th Century Europe and the U.S.

Intermittent: 9 units

This course will explore the interrelations between society and classical and popular music in the nineteenth and twentieth centuries in Europe and the United States. We will examine the importance of different musical forms in the life of society and how music contributed to the making of political consciousness, especially in the twentieth century. In addition to reading assignments, seminar discussions, and research papers in the history of music, students will be taken to the performances of the Pittsburgh Symphony, Pittsburgh Opera, and Chamber Music Society. A supplemental fee of a minimum of \$275 will be charged to subsidize part of the considerable expense of purchasing tickets for concerts and performances. Prerequisite: Availability to attend musical events on several Thursday, Friday, and Saturday evenings.

79-398 Documenting the 1967 Arab-Israeli War

Intermittent: 9 units

This course considers how historians practice their craft in interpreting great events with the Arab-Israeli war of 1967 serving as the case study. Students read recent scholarly accounts of the war and then check them against one another as well as a variety of primary source materials such as memoirs, documents, speeches, newspapers, maps, eye-witness reports and UN resolutions. We will constantly be asking if the sources support the secondary accounts or if there are other interpretations that might lead to different conclusions. We will be examining the texts for tangents left unexplored and possibly worthy of further research. Students should expect a significant reading load, frequent assignments and a major final research paper on a 1967 War-inspired topic.

79-400 Advanced Seminar in Global Studies

Fall and Spring: 12 units

This research seminar is the capstone course for Global Studies majors. The course is designed to give students a chance to define and carry out a research project related to historical or contemporary globalizations. The first few weeks will be devoted to developing a research topic and locating sources. We will then focus on how to interpret and synthesize sources into a coherent and compelling thesis or argument. Projects may be based on in-depth reading of a body of scholarly work, field notes from ethnographic observations, archival research, analysis of literary or visual media, or some combination of these sources. Incorporation of some non-English language sources is strongly encouraged where possible. Independent work, self-initiative, active participation in discussion, and peer evaluations are required. There are several interim deadlines that will be strictly enforced in order to ensure successful completion of the course. Prerequisites: 79-275 and Theoretical and Topical Core must be complete or concurrently enrolled. Corequisite: 79-275.

79-411 Research on Great Islamic Issues According to the Early Sources

Intermittent: 9 units

This course is ONLY offered at Carnegie Mellon in Qatar. The term Islam suggests centuries of history that embody a creed and a civilization with unity and diversity in its rituals and politics. The Islamic world involves "great questions" that differentiate Muslims from one another. Examples include the Shia-Sunni schism or split that has divided Islamdom since the first decades after the death of the Prophet founder in 632; the tensions between unity and sectarianism that relentlessly explode in Muslim countries; the persisting questions of equality and inequality that pertain to gender and race. The works of such historians as Muhammad ibn Ishaq of Medina (704-769), who authored an early biography (Sirat Rasul Allah, Life of the Messenger of Allah), Muhammad ibn Saad of Basra (764-845), who was inspired by Ibn Ishaq, the historian Abu Jafar Muhammad ibn Jarir Al-Tabari (839-923), who authored the multi-volume Tarikh al-rusul wa al muluk (History of the Prophets and Kings), and the 14th-century eminent thinker, Abu Zayd Muhammad Ibn Khaldun, who wrote the Muqaddimah, an Introduction to History, and numerous contemporary scholars help to elucidate part of the problems. Exploring these texts improves the students' grasp of history. This course will be taught as a proseminar that aims at introducing the literature in the English translation and at raising questions. It will broaden deepen the appreciation of history by undergraduate students. As a "specialized" offering reserved for students minoring in history or having successfully completed two courses in history or having the authorization of the instructor, it will meet once a week for 2 and half hours and will discuss at length the sources and the questions.

79-420 Historical Research Seminar

Fall: 12 units

The purpose of this research seminar is to help you conceptualize, design, organize, and execute a substantial research project that embodies and extends the knowledge and skill set you have been developing as a History major at Carnegie Mellon. The identification and collection of relevant primary source data, and the positioning of your project within a relevant historiography, are integral parts of this intellectual task. Along the way, we will strive to hone your written and oral presentation skills, deepen your command of research methodologies and strategies, and sharpen your abilities as a constructive critic of others' research. The seminar seeks to develop these intellectual skills through a combination of in-class, student-led discussions of everyone's research-in-progress, and regular individual consultations with the instructor. Prerequisites: 79-360 or 79-200

79-449 EHPP Project Course

Fall: 12 units

The Ethics, History and Public Policy Project Course is required for the Ethics, History and Public Policy major and is taken in the fall semester of the senior year. In this capstone course, Ethics, History and Public Policy majors carry out a collaborative research project that examines a compelling current policy issue that can be illuminated with historical research and philosophical and policy analysis. The students develop an original research report based on both archival and contemporary policy analysis and they present their results to a client organization in the community.

79-491 Independent Study

Intermittent

An Independent Study is meant for students with a special interest in an area not covered by a formal history course. Readings and other work are negotiated between the student and an individual faculty member.

79-503 Senior Thesis I

Fall: 9 units

Seniors may write a thesis with permission of the Undergraduate Advisor and a designated faculty member who will supervise its completion.

79-504 Senior Thesis II

Spring: 9 units

Seniors may continue their thesis project over a second semester with the permission of the Undergraduate Advisor and the designated faculty member

79-506 Global Studies Internship

Intermittent

This course provides Global Studies majors with a chance to explore global connections in Pittsburgh. Majors, working in close consultation with the Global Studies director and advisor, will arrange an internship with a non-governmental organization (usually in Pittsburgh) whose mission has a global reach. This could include an organization that supports projects in other countries, works with immigrants in the Pittsburgh area, or participates in international policy making/governance. We strongly encourage students to seek out opportunities that require use of a second language. Students will be required to maintain a weekly journal; write a short critical reflection on how the internship connects to academic work; and share their experience with other Global Studies majors. Global Studies advisor and director will assist students with matching their interests to local organizations and identifying an on-site supervisor available to collaborate in the ongoing and final evaluation of the student's work. Prerequisite: Students must be Global Studies majors and obtain permission for the proposed internship from the Global Studies advisor.

Human-Computer Interaction Courses

05-291 Learning Media Design

Fall: 9 units

[IDeATe collaborative course] Learning is a complex human phenomenon with cognitive, social and personal dimensions that need to be accounted for in the design of technology enhanced learning experiences. In this studio course students will apply learning science concepts to critique existing forms of learning media, establish a set of design precedents to guide project work and produce a series of design concepts that support learning interactions in a real-world context. Collaborating in small interdisciplinary teams, students will partner with a local informal learning organization (e.g. museum, after school program provider, maker space) to conduct learning design research studies, synthesize findings, establish learning goals and iteratively prototype and assess design concepts. As final deliverables, students will present their design research findings, design concepts, and prototypes to stakeholders, and draft a media-rich proposal for their learning media concept to pitch to a local funder. Please note that there may be usage/materials fees associated with this course. Please note that there may be usage/materials fees associated with this course. Prerequisite: 05-292

05-292 Learning Media Methods

Spring: 6 units

Learning Media Methods brings together students from across the disciplines to consider the design of mediated learning experiences through a project-based inquiry course. Students will be introduced to a range of design research methods and associated frameworks that explore the cognitive, social and affective dimensions of learning in everyday contexts through readings, invited lectures, in-class activities and assignments. Students will conduct a series of short design research studies to define learning goals and develop supporting design concepts that improve learning outcomes for diverse participants in informal learning settings (e.g. museums, afterschool programs, maker spaces or online). In concept development, we will look at how to position technology and question its role in the setting to engage and foster positive learning interactions. The course will culminate in a media-rich presentation of design concepts to a stakeholder audience, and include an evaluation plan describing how learning outcomes for the project would be assessed.

Corequisite: 80-292

05-320 Social Web

12 units

With the growth of online environments like MySpace, Second Life, World of Warcraft, Wikipedia, blogs, online support groups, and open source development communities, the web is no longer just about information. This course, jointly taught by a computer scientist and a behavioral scientist, will examine a sampling of the social, technical and business challenges social web sites must solve to be successful, teach students how to use high-level tools to analyze, design or build online communities, and help them understand the social impact of spending at least part of their lives online. This class is open to advanced undergraduates and graduate students with either technical or non-technical backgrounds. Course work will include lectures and class discussion, homework, class presentations, and a group research or design project.

Course Website: <http://sweb12.hciresearch.org/>**05-331 Building Virtual Worlds**

Fall: 24 units

This is a project course, where interdisciplinary teams build desktop and immersive (helmet-based) interactive virtual worlds. The course will cover world building, environmental design, non-linear storytelling, and related topics. Students will use 3D Studio Max (CAD modeler), paint tools, such as Adobe PhotoShop and DeepPaint, sound processing tools, and the Alice authoring system (www.alice.org/bvw.htm). Each year, we hold an exhibition in McConomy auditorium to show class projects to the Carnegie Mellon community. The goal of the course is to take students with varying talents, backgrounds, and perspectives and put them together to do what they couldn't do alone. The course is targeted at undergraduates, but grad students may also enroll. To enroll, students must have ONE of the following skills: Modeling with 3D Studio Max Painting using shadow/shape/light in a realistic style; Programming, as evidenced by using the Alice system (www.alice.org); Ability to compose and record original music; Storyboarding Production tracking. The key is that there are no "idea people" in the course; everyone must share in the mechanical creation of the worlds. This is a hands-on course and it takes a lot of time, but most students find it very fulfilling and fun. Note that we don't try to teach artists to program, or engineers to paint; we form teams where everyone does what they're already skilled at to attack a joint project. Class time is roughly split between regular lectures, display/critique of group projects, and guest lectures.

Course Website: <http://www.alice.org/bvw.htm>**05-391 Designing Human Centered Software**

Spring: 12 units

Why are things so hard to use these days? Why doesn't this thing I just bought work? Why is this web site so hard to use? These are frustrations that we have all faced from systems not designed with people in mind. The question this course will focus on is: how can we design human-centered systems that people find useful and usable? This course is an introduction to designing, prototyping, and evaluating user interfaces. If you take only one course in Human-Computer Interaction, this is the course for you. This class is open to all undergrads and grad students, with either technical or non-technical backgrounds. We will cover theory as well as practical application of ideas from Human-Computer Interaction. Course work includes lectures, class discussion, homework, class presentations, and group project.

Course Website: <http://www.hcii.cmu.edu/courses/designing-human-centered-software>**05-392 Interaction Design Overview**

Fall: 9 units

This studio course offers a broad overview of communication and interaction design. Students will learn design methodologies such as brainstorming, sketching, storyboarding, wire framing, and prototyping. Students learn to take a human-centered design approach to their work. Assignments include short in-class exercises as well as individual and team-based projects. Students take part in studio critiques, engaging in critical discussions about the strengths and weaknesses of their own work and the work of others. No coding is required.

05-395 Applications of Cognitive Science

Spring: 9 units

The goal of this course is to examine cases where basic research on cognitive science, including cognitive neuroscience, has made its way into application, in order to understand how science gets applied more generally. The course focuses on applications that are sufficiently advanced as to have made an impact outside of the research field per se; for example, as a product, a change in practice, or a legal statute. Examples are virtual reality (in vision, hearing, and touch), cognitive tutors, phonologically based reading programs, latent semantic analysis applications to writing assessment, and measures of consumers' implicit attitudes. The course will use a case-study approach that considers a set of applications in detail, while building a general understanding of what it means to move research into the applied setting. The questions to be considered include: What makes a body of theoretically based research applicable? What is the pathway from laboratory to practice? What are the barriers - economic, legal, entrenched belief or practice? The format will emphasize analysis and discussion by students. They should bring to the course an interest in application; extensive prior experience in cognitive science is not necessary. The course will include tutorials on basic topics in cognitive science such as perception, memory, and spatial cognition. These should provide sufficient grounding to discuss the applications.

Course Website: <http://www.hcii.cmu.edu/courses/applications-cognitive-science>

05-410 User-Centered Research and Evaluation

Fall: 12 units

This course provides an overview and introduction to the field of human-computer interaction (HCI). It introduces students to tools, techniques, and sources of information about HCI and provides a systematic approach to design. The course increases awareness of good and bad design through observation of existing technology, and teaches the basic skills of task analysis, and analytic and empirical evaluation methods. This is a companion course to courses in visual design (51-422) and software implementation (05-430, 05-431). When registering for this course, undergraduate students are automatically placed the wait list. Students will be then moved into the class, based on if they are in the BHCI second major and year in school e.g. seniors, juniors, etc This course is NOT open to students outside the HCI major. When registering for this course, undergraduate students are automatically placed the wait list. Students will be then moved into the class, based on if they are in the BHCI second major and year in school.

05-411 Cognitive Crash Dummies

6 units

Crash dummies in the auto industry save lives by testing the physical safety of automobiles before they are brought to market. "Cognitive crash dummies" save time, money, and potentially even lives, by allowing computer-based system designers to test their design ideas before implementing them in products and processes. This mini course will review the state of the art of perceptual, cognitive and motor modeling for assessing designs before building working systems. This course will include reading breaking research in predicting different aspects of human performance and building models in established modeling frameworks. No prior experience in human performance modeling is assumed; students from all disciplines are welcome.

05-413 Human Factors

Fall: 9 units

This course uses theory and research from human factors, cognitive science, and social science to understand and design the interactions of humans with the built world, tools, and technology. The course emphasizes current work in applied domains such as automotive design, house construction, medical human factors, and design of information devices. The course also will emphasize not only individual human factors (e.g., visual response, anthropometry) but also the organizational arrangements that can amplify or correct human factors problems. Through reading, discussion, and projects, you will learn about human perceptual, cognitive, and physical processes that affect how people interact with, and use, technology and tools. You will learn why we have so many automobile accidents, voting irregularities, and injuries from prescription medication. You will learn some tried and true solutions for human factors problems, and some of the many problems in human factors that remain. You will also have gained experience in research in this field.

Course Website: <http://www.hcii.cs.cmu.edu>

05-417 Computer-mediated Communication

Spring: 6 units

This course examines fundamental aspects of interpersonal communication and considers how different types of computer-mediated communications (CMC) technologies affect communication processes. Among the topics we will consider are: conversational structure and CMC, tools to support nonverbal and paralinguistic aspects of communication such as gesture and eye gaze, and social and cultural dimensions of CMC. Students will be expected to post to weekly discussion lists, to write a paper on a specific aspect of CMC, and to present a talk on their final project to the class. The course should be appropriate for graduate students in all areas and for advanced undergraduates.

05-418 Design Educational Games

Spring: 12 units

The potential of digital games to improve education is enormous. However, it is a significant challenge to create a game that is both fun and educational. In this course, students will learn to meet this challenge by combining processes and principles from game design and instructional design. Students will also learn to evaluate their games for fun, learning, and the integration of the two. They will be guided by the EDGE framework for the analysis and design educational games. The course will involve a significant hands-on portion, in which students learn a design process to create educational games? digital or non-digital. They will also read about existing educational games and discuss game design, instructional design, learning and transfer, and the educational effectiveness of digital games. They will analyze an educational game and present their analysis to the class.

Course Website: <http://www.hcii.cmu.edu/courses/design-educational-games>

05-430 Programming Usable Interfaces

Spring: 15 units

This course is combines lecture, and an intensive programming lab and design studio. It is for those who want to express their interactive ideas in working prototypes. It will cover the importance of human-computer interaction/interface design, iterative design, input/output techniques, how to design and evaluate interfaces, and research topics that will impact user interfaces in the future. In lab, you will learn how to design and program effective graphical user interfaces, and how to perform user tests. We will cover a number of prototyping tools and require prototypes to be constructed in each, ranging from animated mock-ups to fully functional programs. Assignments will require implementing UIs, testing that interface with users, and then modifying the interface based on findings. Some class sessions will feature design reviews of student work. This course is for HCII Masters students and HCI dual majors with a minimal programming background. Students will often not be professional programmers, but will need to interact with programmers. RECITATION SELECTION: Students taking this course can sign up for either Prototyping Lab recitation. PREREQUISITES: Proficiency in a programming language, program structure, algorithm analysis, and data abstraction. Normally met through an introductory programming course using C, C++, Pascal or Java, such as 15100, 15112, 15127 or equivalent. Students entering this course should be able to independently write a 300-line program in 48 hours. Prerequisites: 15-112 or 15-100 or 15-127

05-431 Software Structures for User Interfaces

Fall: 15 units

SSUI (15-credit, combined lecture and lab) This course considers the basic and detailed concepts that go into building software to implement user interfaces. It considers factors of input, output, application interface, and related infrastructure as well as the typical patterns used to implement them. It will also consider how these components are organized and managed within a well-structured object oriented system. After considering these fundamental concepts in the first portion of the class, the later part will consider advanced topics related to emerging future concepts in user interface design. The course includes an intensive programming lab, either on the topic of mobile or web interfaces. This course is intended for HCII Master, BHCI dual majors and others who wish to understand the structures needed for professional development of interactive systems, and has a strong programming background. PREREQUISITES: Proficiency in a programming language, program structure, algorithm analysis, and data abstraction. WAITLIST LOGISTICS: Note that ALL students who register for this class will initially be placed on a waitlist. Your position on the waitlist is not an indication of whether you will be accepted into the class. Contacting the instructor will not move you off the waitlist. Priority for getting off the waitlist are MHCI students, BHCI students (more senior students first), and then others.

05-432 Personalized Online Learning

Fall: 12 units

Online learning has become widespread (e.g., MOOCs, online and blended courses, and Khan Academy) and many claim it will revolutionize higher education and K-12. How can we make sure online learning is maximally effective? Learners differ along many dimensions and they change over time. Therefore, advanced learning technologies must adapt to learners to provide individualized learning experiences. This course covers a number of proven personalization techniques used in advanced learning technologies. One of the techniques is the use of cognitive modeling to personalize practice of complex cognitive skills in intelligent tutoring systems. This approach, developed at CMU, may well be the most significant application of cognitive science in education and is commercially successful. We will also survey newer techniques, such as personalizing based on student meta-cognition, affect, and motivation. Finally, we will look at personalization approaches that are widely believed to be effective but have not proven to be so. The course involves readings and discussion of different ways of personalizing instruction, with an emphasis on cognitive modeling approaches. Students will learn to use the Cognitive Tutor Authoring Tools (CTAT, <http://ctat.pact.cs.cmu.edu>) to implement tutor prototypes that rely on computer-executable models of human problem solving to personalize instruction. The course is meant for graduate or advanced undergraduate students in Human-Computer Interaction, Psychology, Computer Science, Design, or related fields, who are interested in educational applications. Students should either have some programming skills or experience in the cognitive psychology of human problem solving, or experience with instructional design.

Course Website: <http://www.hcii.cmu.edu/courses/personalized-online-learning>

05-433 Programming Usable Interfaces OR Software Structures for Usable Interfaces

Fall: 6 units

Section A: Programming Usable Interfaces Section B: Software Structures for Usable Interfaces This is a lecture-only course (see 05-430/05-630 or 05-431/631 for the lecture + lab version of these courses) that is intended for those who want to learn how to design and evaluate user interfaces. We will cover the importance of human-computer interaction and interface design, the iterative design cycle used in HCI, an overview of input and output techniques, how to design and evaluate interaction techniques, and end with a discussion of hot topics in research that will impact user interfaces in the coming years. This course is only intended for HCI Masters students or HCI undergraduate majors who have already taken an associated User Interface lab, or non-MHCI/BHCI students interested in the design of user interfaces. PREREQUISITES: There are no prerequisites for this lecture-only course. WAITLIST LOGISTICS: Note that ALL students who register for this class will initially be placed on a waitlist. Your position on the waitlist is not an indication of whether you will be accepted into the class. Contacting the instructor will not move you off the waitlist. Priority for getting off the waitlist are MHCI students, BHCI students (more senior students first), and then others.

05-434 Machine Learning in Practice

Fall and Spring: 12 units

Machine Learning is concerned with computer programs that enable the behavior of a computer to be learned from examples or experience rather than dictated through rules written by hand. It has practical value in many application areas of computer science such as on-line communities and digital libraries. This class is meant to teach the practical side of machine learning for applications, such as mining newsgroup data or building adaptive user interfaces. The emphasis will be on learning the process of applying machine learning effectively to a variety of problems rather than emphasizing an understanding of the theory behind what makes machine learning work. This course does not assume any prior exposure to machine learning theory or practice. In the first 2/3 of the course, we will cover a wide range of learning algorithms that can be applied to a variety of problems. In particular, we will cover topics such as decision trees, rule based classification, support vector machines, Bayesian networks, and clustering. In the final third of the class, we will go into more depth on one application area, namely the application of machine learning to problems involving text processing, such as information retrieval or text categorization.

Course Website: <http://www.hcii.cmu.edu/courses/applied-machine-learning>

05-435 Advanced Fabrication Techniques for HCI

Fall: 12 units

This course will consider how new fabrication techniques such as 3D printing, laser cutting, CNC machining and related computer controlled technologies can be applied to problems in Human-Computer Interaction. Each offering will concentrate on a particular application domain for its projects. This year the course will consider assistive technology. This course will be very hands-on and skills-oriented, with the goal of teaching students the skills necessary to apply these technologies to HCI problems such as rapid prototyping of new device concepts. To this end? Every student in this course will build and take home a 3D printer. (There will be \$400-\$500 cost associated with this course to make that possible. Details on this are still to be determined.)

05-439 The Big Data Pipeline: Collecting and Using Big Data for Interactive Systems

Spring: 12 units

This course covers techniques and technologies for creating data driven interfaces. You will learn about the entire data pipeline from sensing to cleaning data to different forms of analysis and computation.

Course Website: <http://data.cmu.org>

05-499 Special Topics in HCI

Fall and Spring: 12 units

D: Jason Hong - Ubiquitous Personal Smart Agents

05-509 Game Design

Spring: 12 units

05-509 Game Design Spring: 12 units The goal of this course is to prepare students interested in entertainment technology for a career involving design of computer games and other interactive experiences. Students in this course will read and write about game design, and design many games of their own. Do not mistake this for a course in computer game development. This course is focused on the rules and methods of game design, which remain fairly constant regardless of the technology used to develop a game. While technology will play a significant role in our studies, technological details will not be our focus. Students will study and design games of all sorts: card games, dice games, athletic games, story games, and yes, even video games. How to design games, how to design them well, and how to see your designs to completion will be what students master in this course.

05-540 Rapid Prototyping of Computer Systems

Spring: 12 units

This is a project-oriented course, which will deal with all four aspects of project development: the application, the artifact, the computer-aided design environment, and the physical prototyping facilities. The class consists of students from different disciplines who must synthesize and implement a system in a short period of time. Upon completion of this course the student will be able to: generate systems specifications from a perceived need; partition functionality between hardware and software; produce interface specifications for a system composed of numerous subsystems; use computer-aided development tools; fabricate, integrate, and debug a hardware/software system; and evaluate the system in the context of an end user application. The class consists of students from different disciplines who must synthesize and implement a system in a short period of time.

Course Website: <http://www.hcii.cmu.edu/courses/rapid-prototyping-computer-systems>

05-571 Undergraduate Project in HCI

Spring: 12 units

Experiential learning is a key component of the MHCI program. Through a substantial team project, students apply classroom knowledge in analysis and evaluation, implementation and design, and develop skills working in multidisciplinary teams. Student teams work with Carnegie Mellon University-based clients or external clients to iteratively design, build and test a software application which people directly use. Prerequisites: 05-431 or 05-430 or 05-410 or 05-433 or 05-633 or 05-631 or 05-630 or 05-610

Course Website: <http://www.hcii.cmu.edu/courses/undergraduate-project-hci>

05-589 Independent Study in HCI-UG

All Semesters

In collaboration with and with the permission of the professor, undergraduate students may engage in independent project work on any number of research projects sponsored by faculty. Students must complete an Independent Study Proposal, negotiate the number of units to be earned, complete a contract, and present a tangible deliverable. The Undergraduate Program Advisor's signature is required for HCI undergraduate-level Independent Study courses.

Course Website: <http://www.hcii.cmu.edu/independent-study>**05-600 HCI Pro Seminar**

Fall: 6 units

Students will attend weekly HCII Seminar Series of talks given by national leaders in the field of Human-Computer Interaction, attend communication workshops and conflict management workshops.

Course Website: <http://www.hcii.cs.cmu.edu>**05-610 User-Centered Research and Evaluation**

Fall: 12 units

This course provides an overview and introduction to the field of human-computer interaction (HCI). It introduces students to tools, techniques, and sources of information about HCI and provides a systematic approach to design. The course increases awareness of good and bad design through observation of existing technology, and teaches the basic skills of task analysis, and analytic and empirical evaluation methods. This is a companion course to courses in visual design (05-650) and software implementation (05-630, 05-631). This course is NOT open to students outside of the HCI major.

Course Website: <http://www.hcii.cs.cmu.edu>**05-650 Interaction Design Studio**

Spring: 12 units

This course follows Interaction Design Fundamentals (05-651). Students are expected to apply what they have learned about design thinking and methodologies as a starting point for all assignments. Students will work in teams to perform guerrilla research, synthesize data, and consider the needs of multiple stakeholders in their design of mobile services and other intelligent systems. Design concepts go beyond user interfaces to include sensors, controls, and ubiquitous computing. Emphasis is placed on the quality of the students' ideas and their ability to give form to their design concepts. By completing and presenting their work, students will gain skills related to professional UX design practice.

Prerequisites: 51-261 or 05-651 or 51-262 or 51-761

Course Website: <http://www.hcii.cmu.edu/courses/interaction-design-studio>**05-651 Interaction Design Fundamentals**

Fall: 12 units

This studio course introduces students to design thinking and the basic practices of interaction design. We follow a human-centered design process that includes research, concept generation, prototyping, and refinement. Students must work effectively as individuals and in small teams to design mobile information systems and other interactive experiences. Assignments approach design on three levels: specific user interactions, contexts of use, and larger systems. Students will become familiar with design methodologies such as sketching, storyboarding, wire framing, prototyping, etc. No coding is required. This course serves as a prerequisite for Interaction Design Studio (05-650).

05-823 E-Learning Design Principles

Fall: 12 units

This course is about e-learning design principles, the evidence and theory behind them, and how to apply these principles to develop effective educational technologies. It is organized around the book "e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning" by Clark & Mayer with further readings drawn from cognitive science, educational psychology, and human-computer interaction. You will learn design principles 1) for combining words, audio, and graphics in multimedia instruction, 2) for combining examples, explanations, practice and feedback in online support for learning by doing, and 3) for balancing learner versus system control and supporting student metacognition. You will read about the experiments that support these design principles, see examples of how to design such experiments, and practice applying the principles in educational technology development.

Course Website: http://www.learnlab.org/research/wiki/index.php/E-learning_Design_Principles_2013#Course_Details**05-831 Building Virtual Worlds**

Fall: 24 units

This is a project course, where interdisciplinary teams build desktop and immersive (helmet-based) interactive virtual worlds. The course will cover world building, environmental design, non-linear storytelling, and related topics. Students will use 3D Studio Max (CAD modeler), paint tools, such as Adobe PhotoShop and DeepPaint, sound processing tools, and the Alice authoring system (www.alice.org/bvw.htm). Each year, we hold an exhibition in McConomy auditorium to show class projects to the Carnegie Mellon community. The goal of the course is to take students with varying talents, backgrounds, and perspectives and put them together to do what they couldn't do alone. The course is targeted at undergraduates, but grad students may also enroll. To enroll, students must have ONE of the following skills: Modeling with 3D Studio Max Painting using shadow/shape/light in a realistic style Programming, as evidenced by using the Alice system (www.alice.org) Ability to compose and record original music Storyboarding Production tracking Other relevant skills The key thing is that there are no "idea people" in the course; everyone must share in the mechanical creation of the worlds. This is a hands-on course and it takes a lot of time, but most students find it very fulfilling and fun. Note that we don't try to teach artists to program, or engineers to paint; we form teams where everyone does what they're already skilled at to attack a joint project. We are scheduled for 2 weekly meetings, 2.5 hours each. These slots are roughly split between regular lectures, display/critique of group projects, and guest lectures.

Course Website: <http://www.alice.org/bvw.htm>**05-840 Tools for Online Learning**

Fall: 12 units

This course is for students in the METALS program.

Information Communication Technology Courses

04-621 Mobile Social Applications

Spring: 12 units

To be determined by the department

04-990 Research Project

Fall and Spring

Research Project

Information Networking Institute Courses

14-847 Special Topics: Elements of Browser Security

Intermittent: 6 units

Web browsers are becoming an increasingly attractive target for attackers who wish to compromise users' systems or steal data from users. This mini course will study the architecture of modern browsers, vulnerabilities in these browsers, as well as new technologies for enhancing the functionality and security of browsers. Students will be assigned research papers on relevant topics. Topics of study include (but are not limited to) browser encryption, extension and plug-in security, authentication, privacy, browser policies, and JavaScript security. This mini will involve a project as well as small assignments. Students will present their projects in class and write a final report on the projects. Prerequisites: Any of 14-741/18-631/18-730/18-487 with a grade of C or above.

Information Systems:Sch of IS Mgt Courses

95-876 Introduction to Information Security Training and Awareness

Fall: 6 units

Course Description: An awareness and training program is an essential component of any organization that is looking to mitigate security risks caused by human error. This course is designed to prepare students to build their own information security awareness and training program, as part of an organization's information security office or IT department. This course is an elective for graduate students seeking to work or manage an information security and privacy department. The course is open to students seeking to manage an organization's IT program or hold an IT training and awareness management position. The goal of this course is to provide students with the necessary skills and knowledge to design and maintain an information security awareness and training program based on an organization's need.

Institute for Politics and Strategy Courses

84-104 Decision Processes in American Political Institutions

Fall: 9 units

This is an interdisciplinary introduction to the study of politics and government in the United States. It familiarizes the student with the basic structures and processes of American government, but moves beyond the purely descriptive into the realm of the analytical. The main theoretical tools are spatial models of political decision-making, and models of collective action problems. The position taken in this course is that understanding American philosophical ideas about authority, power, and freedom is as central to demystifying the U.S. form of democracy as is understanding how decision-making institutions function. Thus, on one side, this course looks at how American political thought is infused into political institutions and society. On the other side, it investigates institutional arrangements using rationalistic theories. In addition, scientific writings at the intersection of psychology and economics are used to probe the possibility of gaining explanatory leverage on U.S. politics from the perspective of behavioral decision-making theories.

84-124 Freshman Seminar: Democracies and War

Spring: 9 units

This course, a freshman seminar, will introduce students to the role of domestic politics in international conflict and examine the effect of regime type on warfare. In particular, the course will focus on the Democratic Peace and why democracies tend to win the wars they enter. We will discuss a variety of explanations for the Democratic Peace, that is, the tendency of democratic states to avoid war with each other. We will also discuss whether democratic states select wars more carefully, the incentives of democratic leaders when engaging in war, and whether domestic democratic structures provide states with war-fighting advantages with respect to military organization. Finally, we discuss a variety of consequences of the different domestic incentives faced by autocratic and democratic leaders.

84-198 Research Training: Institute for Politics and Strategy

Fall and Spring

This course is part of a set of 100-level courses offered by Dietrich College departments as independent studies for second-semester freshmen, and first- or second-semester sophomores, in the College. In general, these courses are designed to give students some real research experience through work on a faculty project or lab in ways that might stimulate and nurture subsequent interest in research participation. Faculty and students devise a personal and regularized meeting and task schedule. Each Research Training course is worth 9 units, which generally means a minimum for students of about 9 work-hours per week. These courses are offered only as electives; i.e., they cannot be applied toward a college or major requirement, although the units do count toward graduation as elective units. Additional details (including a roster and descriptions of Research Training Courses available in any given semester) are available in the Academic Advisory Center. Prerequisites/ restrictions: for Dietrich College students only; only for second-semester freshmen, or first- or second-semester sophomores; minimum cumulative QPA of 3.0 (at the time of registration) required for approved entry; additional prerequisites (e.g., language proficiency) may arise out of the particular demands of the research project in question.

84-210 Comparative Political Systems

Intermittent: 9 units

Why do some countries thrive while others stagnate? Why are some leaders in power for decades, while others last less than a year? When do political protests lead to regime change? What types of political systems produce the "best" outcomes? In this class students will learn the art and science of comparative politics. We will ask central questions to understanding how political systems emerge, how they change, and how they survive. To do so, students will learn core theories of comparative politics and be introduced to the major methods of inquiry designed to test those theories. Students will learn to evaluate current events through a comparative politics lens and draw reasoned conclusions by considering contemporary issues in light of the theories covered. Students should be prepared to think critically, analyze complex arguments and data, and apply theories to the "real world." Upon completing the course, students will be well-equipped for advanced study of comparative politics, and will also be able to think like a comparative political scientists as they interpret events in the world around them.

84-265 Political Science Research Methods

Fall: 9 units

This course provides an overview of research methods in political science. Students will learn to think like social scientists and develop skills required by the discipline. The course emphasizes the nature of causality and how causal claims can be made in the social sciences. The goal for the class is for students think critically about the strengths and weaknesses of various methodological approaches and identify the methodological tools that are most appropriate for answering different research questions. Furthermore, students will increase their ability to consume political science research from a variety of subfields while also learning to design and present their own research.

Prerequisites: 36-247 or 36-201 or 36-207

84-275 Comparative Politics

Spring: 9 units

The goal of this course is to use the comparative method to learn about the evolution of political ideas and political systems in selected countries. The course is centered on the study of political ideologies, political systems, institutions, and policies. The course will focus on four countries: China, Cuba, Iran and South Africa and the political philosophy that inspired those regimes structures, foundations, and policies. Each of the case studies will allow the students to learn about the ideology, political institutions, and policies, as well as the political and economic transformation of those countries or regions. Students will be expected to compare political ideologies, political institutions, socioeconomic policies and the consequences that those policies have on the society. The course provides the student with both knowledge about critical political ideas and systems and the skills required to analyze and formulate policies.

84-310 International Political Economy and Organizations

Fall: 9 units

This course is an introduction to basic tools of modern political economy such as game theory and hypothesis testing and their applications to study international politics. This course will familiarize students with these theoretical approaches and will demonstrate how we can use them to address contemporary policy questions. We will analyze, for example, how various factors such as the interaction between the state and market, interest groups, and domestic institutions affect trade policies. We will also analyze the roles of international organizations such as the World Trade Organization and the International Court of Justice in the state of "anarchy."

84-320 Domestic Politics and International Affairs

Spring: 9 units

This course will provide students with a broad overview of the recent development in the literature of international relations, focusing on domestic determinants as well as consequences of foreign affairs. We will explore issues in both international security and cooperation. Specific topics include war, regime promotion, foreign aid, trade, and international treaties/ organization. Rather than looking at international system at a macro level, this course aims to investigate the causes and consequences of foreign policies that have roots in domestic political institutions. For example, how does domestic politics constrain or encourage leaders to go to war, sign a trade pact, and send foreign aid? How can citizens incentivize policymakers to achieve desirable foreign policy goals? How do international affairs such as trade, foreign aid, and promotion of democracy affect our lives in a long-run? Do certain foreign policies affect citizens of a democracy and an autocracy differently, and if so, why?

84-321 Autocrats and Democrats

Intermittent: 9 units

The international system is populated by countries with many different types of national governments. A common simplification of the many diverse political systems in the world is to divide them between democratic states and non-democratic states. Non-democratic states are also often further simplified as just "autocracies." This simplification misses many key institutional differences between democracies and autocracies. Furthermore, and even more dangerously, it causes us to overlook key similarities between these two regime types. In this course we have three aims. First, we unpack what is meant by autocracies: What are the different types of non-democratic regimes out there? Second, we evaluate the strategic incentives faced by all types of autocratic leaders and democratic leaders. Finally, we ask what these differences mean for international relations, for democracy-building, and for the future of the organization of national governments. If some of the roots of conflict come from misunderstandings between autocracies and democracies, perhaps a better understanding will contribute to heightened international cooperation, not conflict. An additional goal throughout the course is to build student familiarity with the different types of autocracies out there: We often think of them as dangerous, as unfriendly, or as deeply foreign, simply because we do not understand them or know much about them. Through this exploration, students will be asked to re-consider much of what they've thought about both democracies and non-democracies. Class assignments will ask students to critically examine existing theories of political organization and apply their knowledge to real world cases, both historical and contemporary.

84-322 Attitudes, the Media, and Conflict in International Relations

Intermittent: 9 units

This course examines the sources of political attitudes, the effect of the media on attitudes, & how both interact to influence international conflict, with some attention also to civil war, terrorism, & other forms of violence. The first half of the course considers attitude formation & the media, & the second half focuses on conflict. Specifically, we begin by considering different social science perspectives on attitude formation, drawing from research in behavioral economics, public opinion, decision science, & political psychology. We then consider the effect of the media on attitudes, & the incentives facing leaders of democracies and non-democracies to manipulate the media. Here, we draw primarily from research in comparative politics & IR, but we also cover information science & systems thinking about the spread of ideas. Finally, we consider the effect of attitudes on conflict by examining theories of IR & conflict at multiple levels of analysis: from intra-group conflict, to the relationship between domestic politics & IR, to the "first image" in IR, and to theories of cooperation under anarchy. Throughout, the diverse collection of social science theories will be both illustrated by & critically evaluated through the consideration of contemporary and historical issues, including the rise of China, energy security, human security, & inter-ethnic conflict. Students will leave the class with a deeper understanding of the relationship between ideas & conflict, how the media affects political outcomes, & the diversity of causes & consequences of international conflict. Students will be expected to think critically about the theories and arguments presented they should not simply accept them at face value; rather, students should come prepared to discuss and question the assumptions, relevance, and explanatory power of various ideas presented.

84-323 War and Peace

Intermittent: 9 units

This course explores the conditions that lead to the initiation, escalation, spread, and termination of international conflict as well as the circumstances that promote, preserve, or restore peace. We will explore topics such as balance of power, uncertainty, commitment problems, alliances, arms races, appeasement, and the democratic peace. In addition, we will discuss theories and cases of international mediation and peacekeeping, and evaluate their effectiveness. We will also address the role of the US in promoting international peace. The course emphasizes the application of simple game theoretic models of rational action as tools for assessing relations between nations, coupled with statistical and historical analysis of classes of events. No mathematics beyond high school math is needed for this course.

84-324 Democracies and War

Spring: 9 units

This course will explore the role of domestic politics in international conflict and examine the effect of regime type on warfare. In particular, the course will focus on the Democratic Peace and why democracies tend to win the wars they enter. We will discuss a variety of explanations for the Democratic Peace, that is, the tendency of democratic states to avoid war with each other. We will also discuss whether democratic states select wars more carefully, the incentives of democratic leaders when engaging in war, and whether domestic democratic structures provide states with war-fighting advantages with respect to military organization and soldier initiative. Not open to students who have taken the Freshman Seminar: Democracies and War 84-124.

84-326 Theories of International Relations

Fall: 9 units

This course has three major dimensions. Assumptions and propositions of the leading theories of international relations will be reviewed. This course also seeks to ensure that students clearly understand how newer theoretical approaches to the study of international relations build upon or depart from classical theories. Finally, theories will be discussed in light of historical record by examining major policy decisions and events such as the Cuban missile crisis, the Vietnam War, the Yom Kippur War, the Iran-Iraq War, the Persian Gulf War, the Kargil War, and the Iraq War.

84-330 CMU/WSP: The United States Supreme Court

Fall and Spring: 12 units

Gay marriage. The death penalty. Abortion. Health care. Cell phone privacy. The U.S. Supreme Court has heard cases on all of these topics in recent years, and its decisions ultimately touch the lives of all Americans. In this class we will study the Supreme Court's place in the U.S. legal system. Topics we will cover include: how a case gets to the court, the justices, the role of lawyers before the court, the purpose of oral argument, the court building and its symbolism, and media coverage of the court. Readings will range from newspaper and magazine stories to law review articles. At least once during the semester students will attend an oral argument, and cases currently before the court will be used as a reference point for class discussion. This class is geared not only toward anyone who is interested in the law or government service but also toward anyone interested in working on or being informed about the biggest issues of the day. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-331 CMU/WSP: Congress

Fall and Spring: 12 units

This thematic research seminar will explore the history and current practices of Congress- the first branch under the Constitution- and its role in making public policy. The course is designed to provide students with an understanding of how the congressional system was designed and how it currently operates, combining academic and practical experience. It will be beneficial for students serving in Congressional internships and those considering Congressional staff positions after graduation. This seminar will take advantage of our Washington location by featuring guest speakers and seeking connections to current policy and political debate. In addition to studying the historical development of the Congress from its design in the Constitution to its present operations, we will examine how Congress and its Members relate to the other branches of government, the press, and the public. Topics to be examined include the historical origins of the congressional system, the rules and organization of Capitol Hill, the origins of partisanship, the House and Senate rules, and the history of the Speakership. The class will also examine a number of case studies in congressional legislating. Seminar requirements in addition to the internship include preparation and in-class participation, a substantial research brief and several applied writing assignments related to a policy that currently is or should be before Congress. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-332 CMU/WSP: Washington Media

Fall and Spring: 12 units

This seminar will explore the rapidly changing relationship between the news media, political communication and governing. Washington offers the perfect backdrop with the opportunity to visit iconic institutions, such as the White House Press Room, Washington Post and Newseum, as well as the chance to witness up close the work of journalists, politicians and other political communicators at the top of their profession. Students will keep abreast of current political news in addition to readings on the practice and history of political journalism, communication and propaganda. Each student will complete an original research project, some of which may be adapted for publication in a California news outlet. The course is designed particularly, though not exclusively, for students interning at news organizations, political press offices, speech-writing groups, public relations firms or those with a passion for writing or politics. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-333 CMU/WSP: General Research Seminar

Fall and Spring: 12 units

Research methods in the social sciences are a set of tools that assist us in understanding our world. This seminar is designed to teach you how to be a critical observer of and contributor to that world using these methods. The course has an academic and a practical or civic component. As scholars, we are interested in contributing to a body of knowledge based on the systematic examination of our surroundings; we ask questions, develop theories, collect data to subject to various forms of analysis, and submit results in written form for critique by experts in our field and ultimately for publication in our discipline's scholarly journals. As practitioners and citizens, we are interested in devising solutions to the world's problems; we ask questions, examine relevant bodies of knowledge, develop arguments and communicate them to stakeholders to effect change. We will spend the semester being both scholars and practitioners/citizens, using your internship experiences, DC, and the larger national and global community, to explore questions and answers through each of these lenses with the tools that improve our lives. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-334 CMU/WSP: International Policy

Fall and Spring: 12 units

In debates about U.S. foreign policy, it is often said that "politics stops at the water's edge." While matters of domestic policy- taxes, welfare, regulation, crime, etc.- are legitimately contested in the political arena, foreign policy is argued to be too distant from people's lives and ultimately too dangerous to embroil in the push and pull of domestic politics. In this view, foreign policy is the domain, not of politicians, but of statesmen- leaders who sit above the political fray and attempt to pursue the "national interest" in an enlightened manner. This course challenges this perspective by exploring how domestic political considerations and transnational forces influence the formation of U.S. foreign policy, specifically in the context of relations with Latin America. We will explore the impact of institutional, electoral and psychological pressures, public opinion, interest groups, transnational actors, and the media on decision-making regarding U.S. foreign policy toward Latin America. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-336 CMU/WSP: The Presidency and Executive Branch

Intermittent: 12 units

The White House, located in the heart of downtown Washington and just a ten minute walk from class, is an international symbol that simultaneously highlights the lofty promise of American democracy and reflects the significant flaws in the American experiment. The research seminar will examine the strengths and drawbacks of presidential leadership, the evolving role of the presidency in American culture, and introduce students to some major thematic debates that define presidential politics. The seminar will draw on the city of Washington as an experience through visits to current and former White House aides, news correspondents, and political and policy experts. Seminar topics include how presidents have sought to enact their reform agendas from the New Deal to Reagan's economic program to President Obama's health reform law; how they have struggled to manage foreign affairs while leading the U.S. in wartime; why Congress, the Supreme Court, and the news media thwart and assist presidential agendas at different moments; how presidents have harnessed the "bully pulpit" in the modern age to rally voters to their ideas, push their policies, and position themselves for re-election; and how they have pursued strategies to manipulate a highly volatile, increasingly hostile Washington media climate. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-340 CMU/WSP: American Political Journalism

Fall and Spring: 12 units

This class will explore the relationships among politics, news media and government. It will do so by focusing on particular news events in which the role of the media became an integral part of the story. Some of the sessions may change based on guest speakers' schedules; topics of discussion and readings may also change based on breaking news events. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-341 CMU/WSP: U.S. Foreign Policy in the Middle East

Fall and Spring: 12 units

What are the United States' interests in the Middle East? Who and what determine those interests? And how are those interests pursued? This course addresses these questions in two parts. First, we will consider the domestic American debate on foreign policy in the Middle East, exploring key Middle Eastern trends; America's regional interests; and the political actors and factors that shape U.S. policy in the Middle East. We will then turn to America's actions and relationships in the region, assessing American policy dilemmas across a wide variety of countries and events. Students should leave this class with a strong understanding of the challenges that the U.S. faces in the Middle East, as well as an informed viewpoint regarding how well America is meeting those challenges. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-342 CMU/WSP: Fiscal Policy-Making in the U.S.

Intermittent: 12 units

The purpose of this course is to give students a comprehensive overview of the major issues facing U.S. fiscal policy, with special emphasis on structural issues, such as the problems facing the major entitlement programs: social security, and Medicare/Medicaid. The course will emphasize the economic aspects of fiscal issues, but will also address their historical roots and political aspects. For example, its discussion of expenditure will address the constraints posed by the budget system and the political process on expenditure control. Similarly, it will explore how politics has shaped the tax system, and why the government policy discussion is so often stymied. Washington-based experts in the field will be included in presentations and class meetings. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-343 CMU/WSP: Sports, Politics, and Society

Spring: 12 units

Few things have characterized mass culture in the 20th century more consistently and thoroughly than sports. Particularly in their team variety, there is not one industrial country in the world that does not possess at least one major team sport which has attained hegemonic dimensions in that country's culture in the course of the previous century. There can simply be no doubt that team sports as a form of mass culture have been among the most essential ingredients of public life in the 20th century. If anything, their cultural importance has increased in the beginning years of the 21st and shows every indication that this importance will grow in years to come. Why has this been the case? And how did this happen? Moreover, why did the United States deviate from much of the rest of the industrial world not in terms of the presence of such sports, but in their number and kind? Briefly put, why are baseball, football and basketball (as well as ice hockey to a certain extent) the hegemonic team sports that defined American mass culture throughout the 20th century whereas no other industrial country has more than two such hegemonic team sports, most often indeed only one? soccer? Why has this sports map remained so stable throughout a highly volatile and ever-changing century? Will this stability persist into the new millennium or will new forces challenge these hegemonic sports and contest them in their respective cultural space? THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-344 CMU/WSP: Politics and Poems: Writing Verse in DC

Spring: 12 units

This course is a space for writing and discussing poems in the nation's capital. The course title takes as inspiration the name of the renowned independent bookstore (Politics and Prose) in Washington, but with a twist. Accordingly, most of the assigned texts will be by DC area poets who will visit the class as special guests. This course is as much about reading poems as writing (and revising) them. Students will attend at least one live literary event to experience poetry as performance, as well as visit a museum or gallery to use the visual or plastic arts as a springboard for their poetry. Finally, students will acquire and hone the vocabulary necessary to offer constructive feedback on one another's work. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-345 CMU/WSP: Cultural Policy: Cultural Heritage and Cultural Diplomacy

Fall: 12 units

This course is designed to introduce students to the broad implications of the control, management, investigation, presentation, and interpretation of collections of things considered of cultural significance. A tradition of more than 400 years can be traced from the sixteenth-century European collections made by a network of nobles, merchants, and explorers to the universal museums of the nineteenth century. Many of the universal museums established in the nineteenth century persist today as national museums, and of these, the Smithsonian Institution can be taken as a model. Participants in this seminar will be introduced to the contemporary workings of museums, and will use frameworks provided to examine how constituent museums that form part of the Smithsonian can be understood as sites of knowledge creation. This course frames museums within contemporary issues of cultural heritage (repatriation, the international traffic in antiquities) and cultural diplomacy (implementation of the UNESCO Convention, development and circulation of collaborative international exhibitions). Students will gain a basic understanding of the structure of western museums; the history of the universal museum; relationships between cultural property and national identity; and contemporary cultural policy issues. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-346 CMU/WSP: Race and Politics in the American City

Fall: 12 units

The purpose of this seminar is to equip students to think deeply and critically about racial politics in the American city in general- and about racial politics in the American city of Washington, DC, in particular. The seminar will begin with an introduction to a set of concepts fundamental to our subject- race, consciousness, racism, political action- and then move on to central features of city politics with race prominently in mind. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-347 CMU/WSP: Lobbying, Money, and Influence in Washington

Fall and Spring: 12 units

This course will be an intense examination of lobbying in Washington with particular attention given to the role of money and campaign finance in the operation of what has become a highly sophisticated and poorly understood network of advocacy and influence. It will provide a basic understanding of three different but interrelated knowledge sets: the Congress, political money and lobbying by interest groups. Student should understand that while the lectures are focused on those individual subject areas and that the semester is divided into three separate sections for that purpose, the readings later in the term will often relate to earlier lectures. This is done with the intent of "connecting the dots" among all these somewhat diverse topical areas. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-348 CMU/WSP: Spies! The Politics of Intelligence

Intermittent: 12 units

In this course students will be introduced to recent issues concerning intelligence, such as intelligence failure, reform, and oversight, focusing particularly on how the change in US intelligence in the post-9/11 context has increasingly emphasized domestic - or "homeland" - intelligence. Students will gain a working understanding of the different types of intelligence, the range of responsibilities that the different IC members hold, and the relationship between intelligence and the policy-making process. Beyond the technical aspects of the intelligence function, students will explore the political context that frames intelligence operations and learn how the three branches of government both collaborate and conflict to utilize this resource. They will learn how integral intelligence information is to high-level government decision-making and the function of foreign policy. Finally, students will consider some of the major normative questions regarding intelligence, such as: what the appropriate role for intelligence should be in a democracy, how transparent intelligence should be to the public, and how its vast array of activities should be supervised. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-349 CMU/WSP: The Theater of Politics

Intermittent: 12 units

Over the years, this course has canvassed the Washington theater scene and discovered a wealth of politically and socially attuned material on DC stages. Washington has, rather surprisingly, emerged as the second most vibrant theatrical city in the nation, surpassing Chicago and Los Angeles in number of performances offered, audience in attendance, and union actors appearing in Equity-contracted productions. The city now boasts some of the finest classical flagship and culturally specific theaters in the country. This advent of a robust theater scene planted in the seat of power has created a unique cultural profile; that of an artistic force able to speak truth to power. Yet oftentimes, theatrical institutions are constricted by the divided nature of the audience they play for, or the critical community that critiques them, or differing notions about the purpose of theater. What kind of portraits are emerging from area theaters in this politicized capital? What are the practical politics within these institutions that seek to engage and entertain their patrons? In addition to introducing students of the wonders of consistent theater-going with dynamic post-performance discussions with the artists who make the art, our focus will concern politically oriented works. There is an extra fee of \$250 with this course that the student is responsible for paying. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-350 CMU/WSP: Campaigns and Elections

Fall and Spring: 12 units

This class will teach you how to better understand the fundamental factors that drive elections in America and to learn some of the skills employed by political professionals. Many of your assignments will require you to apply the lessons of this class to real time events. Pundits and other observers have already generated a phenomenal amount of analysis and commentary about the 2012 election and occasionally they have even been right. The goal in this class is to go beyond the spin and hyperbole of many election commentators and understand how voters decide and how strategists persuade. And, to give you some of the technical skills to get an interesting job with a campaign. This class will combine the insights of campaign professionals with insight from the study of previous campaigns and core academic knowledge. It will combine theory, practice, and exploration, taking the insights of political scientists and political practitioners and rolling them into one. Particular emphasis on Congress, the White House, executive bureaucracy, interest groups, and media. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-360 CMU/WSP: Internship Seminar

Fall and Spring: 12 units

The internship is the experiential "core" of the Washington Semester Program. Students intern three days per week, for approximately 24-25 hours, in offices from Capitol Hill to the White House and including opportunities in cabinet agencies, nonprofit institutions, museums, advocacy groups, policy think tanks, cultural institutions, and news organizations. Through the internship, students gain professional experience and make long-lasting professional and personal contacts. In addition, students meet once a week with the CMU internship faculty for a 2-hour seminar to report and reflect on their internship experiences, and address pressing current issues from the perspective of their internship organization. In addition, the weekly seminar typically includes 1-2 CMU alumni from the Washington, DC, area. Their personal and professional experiences become part of the seminar conversation, and they make themselves available to students as ongoing sources of information and advice. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.

84-362 Diplomacy and Statecraft

Fall: 9 units

This course introduces students to the fundamental principles of the art of statecraft; major concepts and theories of diplomacy; and the main tools of diplomatic practice and key venues in the Middle East, Africa, Asia, the Americas and Europe. Students will examine the relationship between diplomatic and military power; the use of economic measures; the role of public diplomacy; and the challenges of multilateral negotiations. Contemporary global conflicts will serve as important units of analysis, including the current state of affairs in countries including Russia, Iraq, Iran, Syria, Libya, Afghanistan, Somalia, North Korea, and Pakistan, among others.

84-380 Grand Strategy in the United States

Fall: 9 units

This course introduces students to the concept of grand strategy in the United States, broadly defined as the combination of diplomatic, economic, military, and political factors used by American presidents and their administrations to advance U.S. interests throughout the world. In the context of highly interdependent domestic and international politics, leaders must develop strategies that address a diverse range of internal, state, and non-state challenges while also dealing with the myriad challenges resulting from globalization, or the intersection of international politics, culture, markets, and technology. This course will review American diplomatic history over the ages, with a focus on both Cold War and post-Cold War American presidencies and their respective approaches to defending American national security whilst also playing a role as one of the world's leading powers.

84-386 The Privatization of Force

Spring: 9 units

This course considers different forms of privatized force and security over time and across various strategic contexts, from historical mercenarism up to modern-day private military and security contractors. While going through the historical and modern material chronologically, the course considers the various issues that arise with each form of privatized force, including questions that arise regarding the state's monopoly on violence, legal and humanitarian issues, and civil-military relations. These range from the theoretical concerns regarding modern definitions of the state, to practical operational-level concerns pertaining to field coordination issues between the military and private contractors in modern conflicts.

84-389 Terrorism and Insurgency

Spring: 9 units

This course offers an introduction to the study of terrorism and insurgency, and government policies to counter these types of domestic political violence. We will read and discuss recent leading academic and policy research that addresses questions such as what are the causes of terrorism and insurgency? Who becomes a terrorist or an insurgent? Do terrorists and insurgents achieve their goals? What works and what does not work in counterterrorism and counterinsurgency? The goal of this course is to demonstrate how theoretical and empirical approaches in social sciences can be used to answer questions about terrorism and insurgency. In addition, the course is designed to help students critically evaluate the arguments in the literature, and to be able to engage debates about these issues in informed way.

84-393 Legislative Decision Making: U.S. Congress

Spring: 9 units

This course analyzes decision-making by the United States Congress. The course examines legislative behavior by focusing on the way Congress is organized (institutional and constitutional structure) and the ways legislators, voters, and various other parties interact (strategic constraints). Students will both learn the legislative process and explore the influence of norms, rules, expectations, incentives and, perhaps most important of all, the power of the electorate in influencing legislative outcomes and policy. Elections, voting decisions, committee assignments, political party power, and intra-branch relations across the Federal government are some of the topics into which we will delve. This course does not require any prior knowledge of the U.S. Congress, and there are no prerequisites for the course.

84-402 Judicial Politics and Behavior

Intermittent: 9 units

This course is a survey of research and insight into one of the most unique American government institutions: the judiciary. Rather than exclusively reading case law (as one would do in a Constitutional Law class), this course examines court structure, rules of law and, most importantly, judges as actors within an institutional setting. We will focus on how rules, norms, and expectations guide the decisions, actions, and range of options available to judges. Here we will study the nature of judicial decision-making and its antecedents, the organization of the judicial branch and its implications for behavior, and the strategic interactions both within courts and between the courts and the more "political" branches of government. The course will look at state and federal courts within the United States, supplemented with examples from international jurisdictions. Material from law, history, economics, political science, sociology, and psychology will be introduced throughout the semester. Although some of the literature uses empirical and/or game theoretical models, students are not expected to have mastered these tools prior to taking the course.

84-414 International and Subnational Security

Spring: 9 units

The course explores various international and domestic security challenges that contemporary states face. Specifically, the course will survey the most recent research in political science that addresses the questions of why states choose to enter violent conflicts as opposed to settling disputes peacefully, how states may improve their security in the international arena, and how states may improve their security in the domestic environment. We will focus in depth on the bargaining explanations for war, democratic/regime similarity/capitalist peace, deterrence, interdependence, insurgency, and terrorism. The course draws heavily upon research that employs game theoretic and computational models to develop logical arguments about political events and statistical analysis to test whether empirical reality follows the outlined theoretical predictions. The course will provide solid training in graphical literacy. Students will evaluate table-form output from statistical analysis, interpret graphical output, and receive a notion of game theoretic and computational models.

84-450 IRP Capstone Policy Forum

Fall and Spring

The Policy Forum course takes a critical look at decision making in domestic politics and US foreign policy. It does so through weekly roundtable discussions with a diverse set of thought leaders. Based on intellectually significant essays that students are expected to read in advance of each class, these discussions give students an opportunity to ask probing questions about the three branches of the US government, media, embassies, advocacy groups, international organizations, and nongovernmental organizations.

84-498 Undergraduate Research

Fall and Spring

Students conduct research under the supervision of an Institute for Politics and Strategy faculty member. Students who wish to engage in research should seek out a faculty member whose interests are appropriate to the research. Prerequisite: Students must also complete an "Independent Study/Research for Credit" form, available from the Academic Program Manager. Permission of a faculty sponsor.

84-499 Independent Study

Fall and Spring

Students conduct independent academic study under the supervision of an Institute for Politics and Strategy faculty member. Students who wish to engage in an independent study should seek out a faculty member whose interests are appropriate to the topic. Students must also complete an "Independent Study/Research for Credit" form, available from the Academic Program Manager. Prerequisite: Permission of a faculty sponsor.

84-505 Undergraduate Internship

Fall and Spring

An internship is an approved and monitored work experience that can be related to an academic field of study through active reflection and specific learning goals. Students will be in regular contact with a faculty member in the Institute for Politics and Strategy, who will assign and evaluate academic work. Internships are available for 3, 6, or 9 units, depending on the type and amount of academic work produced. Students are responsible for finding their own internships and faculty sponsors, although assistance is available through the Academic Program Manager.

Institute for Software Research Courses**08-200 Ethics and Policy Issues in Computing**

Spring: 9 units

Should autonomous robots make life and death decisions on their own? Should we allow them to select a target and launch weapons? To diagnose injuries and perform surgery when human doctors are not around? Who should be permitted to observe you, find out who your friends are, what you do and say with them, what you buy, and where you go? Do social media and personalized search restrict our intellectual horizons? Do we live in polarizing information bubbles, just hearing echoes of what we already know and believe? As computing technology becomes ever more pervasive and sophisticated, we are presented with an escalating barrage of decisions about who, how, when, and for what purposes technology should be used. This course will provide an intellectual framework for discussing these pressing issues of our time, as we shape the technologies that in turn shape us. We will seek insight through reading, discussion, guest lectures, and debates. Students will also undertake an analysis of a relevant issue of their choice, developing their own position, and acquiring the research skills needed to lend depth to their thinking. The course will enhance students' ability to think clearly about contentious technology choices, formulate smart positions, and support their views with winning arguments.

08-202 Computational Approaches to Social Complexity

Spring: 9 units

Everything is connected! From small groups to economic markets to global societies - interactions among people, organizations, technology, and policies lead to complex systems. These connected systems cannot be described with simple equations but rather with networks, non-linearities and tipping points. This course covers a set of computational approaches to analyzing and understanding the dynamics of the social world. Techniques include data capture, social network analysis, advanced information visualization, and agent based simulation. Students will engage in hands-on projects learning these techniques to explain and predict social changes arising from the complexity of everyday life.

08-300 Constructing Appropriate Technology

Fall: 12 units

08-300 Constructing Appropriate Technology (9 units) How can you make sure the technology you create will be viable? This course teaches students how to conduct research and develop technology across disciplines, so that the resulting technology is provably appropriate for a given personal, societal, organizational, and/or legal context. Students learn to fuse scientific research methods (naturalistic observation, survey, interviews, and experimentation), which describe existing phenomena, with computer science methods and engineering approaches. Topics include formulating problem statements, modeling real-world constraints, including end-user participation, determining validity, assessing generalizability, generating guarantees, and a unifying paradigm ("Technology Dialectics") for providing provably appropriate solutions. Students also gain hands-on experience working jointly on the construction of real-world technology <http://privacy.cs.cmu.edu/courses/dialectics/index.html>

Course Website: <http://privacy.cs.cmu.edu/courses/dialectics/index.html>**08-302 Introduction to Network Science**

Fall: 9 units

Everything is connected - from your friends, to everyone at CMU, to economic markets, disease outbreaks, and global societies. Relationships and flows of information among people and organizations form complex systems that are the fundamental structures governing our world, yet defy easy understanding. To analyze these interconnected systems we must turn to network science. This course covers the mathematical and graph theoretical foundations of network science, as well as theories and algorithms for analyzing and visualizing structures and dynamics of networked systems. Topics covered in this class include: centrality metrics, community detection, diffusion processes, scale-free and small-world networks, social media analytics, and network visualization. A special emphasis is on algorithmic challenges and solutions in the context of big data networks. Students will engage in hands-on projects learning network science, solidifying their mathematical and graph theory knowledge and learning how to apply it to a range of real world problems. This course is open to students in all majors who have earned a C or better in 15-151 or 21-127.

Prerequisites: 21-127 or 15-151

08-340 Green Computing

Spring: 9 units

Energy is a key societal resource. However, our energy usage is rising at an alarming rate and therefore it has become critical to manage its consumption more efficiently for long term sustainability. This course introduces students to the exciting area of "Green Computing", and is organizationally divided into two tracks. The first track is "Energy-Efficient Computing", which considers the state of the art techniques for improving the energy efficiency of mobile devices, to laptop and desktop class computers and finally to data centers. We will cover energy efficiency across the hardware/software stack, starting from the individual components like processors and radio interfaces to system level architectures and optimizations. The second track is "Applying Computing towards Sustainability", covering topics that leverage computing to reduce the energy footprint of our society. In particular, we will focus on Smart Buildings and the Smart Grid, covering topics such as sensing, modeling and controlling the energy usage of buildings, new operating systems or software stacks for the smart infrastructure, as well as the privacy and security issues with the new "internet of things". The goal of this course is to help students acquire some of the knowledge and the skills needed to do research in this space of "Green Computing". Although the course is listed within SCS, it should be of interest to students in several departments, including ECE, MechE, CEE, EPP and Architecture.

Course Website: <http://www.cs.cmu.edu/~yuvraja/courses/08-840>**08-463 Service Innovation**

Spring: 6 units

This course introduces students to the concept of services and their increasing role in the global economy and global employment, and explores services as a part of a goods-services continuum ranging from products or goods to service encapsulation of products to pure services. Service innovation is defined, and contrasts drawn between service and product innovation. Service innovation mechanisms and barriers to innovation are explored, as are organizational outcomes and measurement of service innovation. Course discussion identifies selected issues in service innovation, such as the innovation value chain, co-creation of service innovations, service innovation for sustainability, innovation in public service, changes in employment, globalization of service innovation, service design, or the ethics of service innovation; and assesses the impact of these on future service innovation agendas.

08-532 Law of Computer Technology

Fall: 9 units

The Law of Computer Technology A survey of how legislatures and courts cope with rapidly advancing computer technologies and how scientific information is presented to, and evaluated by, civil authorities. The course is also an introduction to the legal process generally and the interaction between the legal system and technology organizations. Topics include: patents, copyrights in a networked world, law of the Internet, free speech, data security, technology regulation, international law, and transborder crime. Open to juniors, seniors and graduate students in any school. Open to sophomores by permission of the instructor. Prerequisites: none.

08-533 Privacy, Policy, Law and Technology

Fall and Spring: 9 units

This course focuses on policy issues related to privacy from the perspectives of governments, organizations, and individuals. We will begin with a historical and philosophical study of privacy and then explore recent public policy issues. We will examine the privacy protections provided by laws and regulations, as well as the way technology can be used to protect privacy. We will emphasize technology-related privacy concerns and mitigation, for example: social networks, smartphones, behavioral advertising (and tools to prevent targeted advertising and tracking), anonymous communication systems, big data, and drones. This is part of a series of courses offered as part of the MSIT-Privacy Engineering masters program. These courses may be taken in any order or simultaneously. Foundations of Privacy (Fall semester) offers more in-depth coverage of technologies and algorithms used to reason about and protect privacy. Engineering Privacy in Software (Spring semester) focuses on the methods and tools needed to design systems for privacy. This course is intended primarily for graduate students and advanced undergraduate students with some technical background. Programming skills are not required. 8-733, 19-608, and 95-818 are 12-unit courses for PhD students. Students enrolled under these course numbers will have extra assignments and will be expected to do a project suitable for publication. 8-533 is a 9-unit course for undergraduate students. Masters students may register for any of the course numbers permitted by their program. This course will include a lot of reading, writing, and class discussion. Students will be able to tailor their assignments to their skills and interests. However, all students will be expected to do some writing and some technical work.

Course Website: <http://cups.cs.cmu.edu/courses/privpolawtech.html>**08-540 Green Computing**

Spring: 9 units

Energy is a key societal resource. However, our energy usage is rising at an alarming rate and therefore it has become critical to manage its consumption more efficiently for long term sustainability. This course introduces students to the exciting area of "Green Computing", and is organizationally divided into two tracks. The first track is "Energy-Efficient Computing", which considers the state of the art techniques for improving the energy efficiency of mobile devices, to laptop and desktop class computers and finally to data centers. We will cover energy efficiency across the hardware/software stack, starting from the individual components like processors and radio interfaces to system level architectures and optimizations. The second track is "Applying Computing towards Sustainability", covering topics that leverage computing to reduce the energy footprint of our society. In particular, we will focus on Smart Buildings and the Smart Grid, covering topics such as sensing, modeling and controlling the energy usage of buildings, new operating systems or software stacks for the smart infrastructure, as well as the privacy and security issues with the new "internet of things". The goal of this course is to help students acquire some of the knowledge and the skills needed to do research in this space of "Green Computing". Although the course is listed within SCS, it should be of interest to students in several departments, including ECE, MechE, CEE, EPP and Architecture.

Course Website: <http://www.cs.cmu.edu/~yuvraja/courses/08-840>

08-541 Hardware and Software Systems for Smart Homes and Buildings

Spring: 9 units

Smart automation in the home and buildings hold tremendous promise to enhance the quality of our lives and improving energy efficiency. In this course we will take a hands-on approach towards building hardware and software systems within the context of these emerging smart homes and smart building domains. You will learn about embedded systems and how to choose the appropriate one for different smart home projects, including understanding the advantages and limitations of such platforms. You will learn about sensors and how to interface them with the real world to be able to get useful and actionable data. You will learn about designing systems from ground up, including schematic and PCB layouts. You will learn about different radio technologies, so that you can build a network of sensors that can communicate with each other. You will also learn about storing the sensor data for visualization, analysis and presentation both locally and to the cloud. The course will comprise of hands-on exercises, which build upon each other as the course progresses through the semester. We will likely use an embedded platform such as the Raspberry Pi or the BeagleBone Black (cost between \$75 and \$100) and each student will be expected to buy one of these platforms to use throughout the semester. From time to time we will also discuss latest research papers and case studies on topics related to smart home and buildings, with the focus towards deployed systems. The course grade will be computed based on the homework and mini-project assignments, class presentations and a semester long course project. It is expected that students will have some programming background, are excited to take on hands-on projects, and want to learn how to build end-to-end systems for smart homes. As a side effect, perhaps some of your ideas will lead to the next NEST (sold for \$3.2B in 2014!).

08-671 Java for Application Programmers

Fall and Spring: 6 units

This course provides an intensive exploration of computer programming in the Java Language for Masters students who have had some prior, but perhaps limited, programming experience in Java or in some other programming language. The course starts with a review of the fundamental topics of programming in Java (data types, operators, control structures) along with discussions of object oriented programming (classes, instances, and class hierarchies). After covering the basics we move on using Java to cover simple graphical user interfaces (using Swing), file I/O, concurrency (i.e., threads), network I/O (HTTP), simple data structures (lists and maps). Students are required to have a reasonably modern laptop computer on which install the Java software used for this course.

08-672 J2EE Web Application Development

Fall: 6 units

This course will introduce concepts in programming web application servers. We will study of the fundamental architectural elements of programming web sites that produce content dynamically. We will be demonstrating the course using Java Servlets and Java Server Pages. We will also cover the related topics as necessary so that students may build significant applications. Such topics are expected to include: HTML, CSS, HTTP, Relational and Non-Relational Databases, Object-Relation Mapping Tools, Security Issues, AJAX, and Cloud Deployment. Students are required to be familiar with Java Programming before taking this course. Those who are not are encouraged to take 08-671 in mini 1 before taking this course. Students are required to have a reasonably modern laptop computer on which install the Java software used for this course.

08-733 Privacy, Policy, Law and Technology

Fall: 12 units

This course focuses on policy issues related to privacy from the perspectives of governments, organizations, and individuals. We will begin with a historical and philosophical study of privacy and then explore recent public policy issues. We will examine the privacy protections provided by laws and regulations, as well as the way technology can be used to protect privacy. We will emphasize technology-related privacy concerns and mitigation, for example: social networks, smartphones, behavioral advertising (and tools to prevent targeted advertising and tracking), anonymous communication systems, big data, and drones. This is part of a series of courses offered as part of the MSIT-Privacy Engineering masters program. These courses may be taken in any order or simultaneously. Foundations of Privacy (Fall semester) offers more in-depth coverage of technologies and algorithms used to reason about and protect privacy. Engineering Privacy in Software (Spring semester) focuses on the methods and tools needed to design systems for privacy. This course is intended primarily for graduate students and advanced undergraduate students with some technical background. Programming skills are not required. 8-733, 19-608, and 95-818 are 12-unit courses for PhD students. Students enrolled under these course numbers will have extra assignments and will be expected to do a project suitable for publication. 8-533 is a 9-unit course for undergraduate students. Masters students may register for any of the course numbers permitted by their program. This course will include a lot of reading, writing, and class discussion. Students will be able to tailor their assignments to their skills and interests. However, all students will be expected to do some writing and some technical work.

Course Website: <http://cups.cs.cmu.edu/courses/privpolawtech.html>**08-781 Mobile and Pervasive Computing Services**

Spring: 9 units

With over 6 billion mobile phone users worldwide, including well over a billion smart phone users, new wireless and pervasive computing applications and services are changing the way enterprises interact with customers and employees. The explosion in smart phone ownership along with the deployment of 4G networks is leading to a slew of new mobile apps and services. They range from mobile commerce services to wireless enterprise apps and mobile social networking apps, all the way to more futuristic pervasive computing scenarios where phones interact with a number of other everyday objects (e.g. smart homes, smart cars, smart glasses, health/fitness sensors). These apps and services are emerging as part of an increasingly rich ecosystem where context awareness and intelligent predictive technologies are used to offer increasingly personalized experiences to users. This same ecosystem has emerged as the engine behind increasingly targeted marketing and advertising scenarios that also raise challenging privacy issues. The course objective is to introduce participants to the technologies, services and business models associated with Mobile and Pervasive Commerce. It also provides an overview of future trends and ongoing research. You will learn to evaluate critical design tradeoffs associated with different mobile technologies, architectures, interfaces and business models and how they impact the usability, security, privacy and commercial viability of mobile and pervasive computing services and apps. Topics include Mobile Communications, Mobile OS, Mobile Web technologies including app development, Mobile Security, Mobile Payments, Mobile Web Apps and Services (e.g. Mobile Entertainment, Mobile Banking, Mobile, Mobile Social Networking, Mobile Health, etc.), Location-Based Services, RFID, Mobile Enterprise Apps, Pervasive Computing Applications, Context awareness, intelligent assistant technologies, and privacy.

Course Website: <http://www.normsadeh.com/ms-course-overview>

08-801 Dynamic Network Analysis

Spring: 12 units

Who knows who? Who knows what? Who communicates with whom? Who is influential? How do ideas, diseases, and technologies propagate through groups? How do social media, social, knowledge, and technology networks differ? How do these networks evolve? How do network constrain and enable behavior? How can a network be compromised or made resilient? Such questions can be addressed using Network Science. Network Science, a.k.a. social network analysis and link analysis, is a fast-growing interdisciplinary field aimed at understanding simple & high dimensional networks, from both a static and a dynamic perspective. Across an unlimited application space, graph theoretic, statistical, & simulation methodologies are used. An interdisciplinary perspective on network science is provided, with an emphasis on high-dimensional dynamic data. The fundamentals of network science, methods, theories, metrics & confidence estimation, constraints on data collection & bias, and key research findings & challenges are examined. Illustrative networks discussed include social media based (e.g., twitter), disaster response, organizational, semantic, political elite, crises, terror, & P2P networks. Critical procedures covered include: basic centralities and metrics, group and community detection, link inference, network change detection, comparative analytics, and big data techniques. Applications from business, science, art, medicine, forensics, social media & numerous other areas are explored. Key issues addressed: Conceptualization, measurement, comparison & evaluation of networks. Identification of influential nodes and hidden groups. Network emergence, evolution, change & destabilization. Graduate course taught every other year. Prerequisite: Undergraduate-level statistics course or instructor permission. Linear algebra is recommended. Students are encouraged to bring & use their own data, or to use provided data.

08-805 Engineering Privacy in Software

Spring: 12 units

This section is for Ph.D. students; all other students should enroll in 08-605. Privacy harms that involve personal data can often be traced back to software design failures, which can be prevented through sound engineering practices. In this course, students will learn how to identify privacy threats due to surveillance activities that enhance modern information systems, including location tracking, behavioral profiling, recommender systems, and social networking. Students will learn to analyze systems to identify the core operating principles and technical means that introduce privacy threats, and they will learn to evaluate and mitigate privacy risks to individuals by investigating system design alternatives. Strategies to mitigating privacy risk will be based on emerging standards and reliable privacy preference data. Students will have the opportunity to study web-, mobile- and cyber-physical systems across a range of domains, including advertising, healthcare, law enforcement and social networking. In addition, students will know how, and when, to interface with relevant stakeholders, including legal, marketing and other developers in order to align software design with privacy policy and law.

08-810 Computational Modeling of Complex Socio-Technical Systems

Spring: 12 units

Social and cultural systems are complex. Whether considering world transforming events such as the Arab Spring or the impact of health care reforms, the interactions among people, technology, and organizations can generate unanticipated outcomes. Computer simulation is a critical methodology for explaining and predicting these events. In this course, the basics of simulation modeling, design, testing and validation are covered. Different simulation approaches are contrasted such as agent-based modeling and system dynamics.

Integrated Innovation Institute Courses

49-300 Special Topic: Integrated Product Conceptualization

Fall: 12 units

The Integrated Product Conceptualization course focuses on introducing students to some of the thinking, basic skills and methods used by industrial design, engineering, and business to generate new consumer product proposals within integrated teams. Teams will progress through three phases 1) identifying opportunities for new products or services, 2) understanding those opportunities through stakeholder research, value opportunity analysis, and competitive landscape assessment, then selecting one of which to focus, 3) conceptualizing the opportunity with the goal of meeting the value proposition. This course will combine lecture, and studio activities including the generation of 2D visual representation skills and 3D low-fidelity physical modeling in support of course work. Prerequisites: 18-090 or 16-223 or 15-104 or 60-223 or 62-150

49-700 Engineering Design Fundamentals

Fall: 6 units

This course will teach the basic principles and philosophies of engineering design (with emphasis on mechanical engineering). Topics include stress analysis and fracture, heat transfer, kinematics, and systems packaging. Students will learn the issues engineers must consider during design of commonly produced products. Class includes lectures and labs. This course is required for Master of Integrated Innovation for Products & Services (MIIPS) students who do not have an engineering background. This course is intended for MII-PS students; all other students by permission of the instructor.

49-701 Industrial Design Fundamentals

Fall: 6 units

IDF in Context introduces non-design students of the MII-PS program to the placement of products in the marketplace. Through lectures, discussions and assignments students will gain an understanding of the evolution of products in preparation to conceive of products in the IPD Capstone course. This course is intended for MII-PS students; all other students by permission of the instructor.

49-702 Business Fundamentals

Fall: 6 units

The purpose of the class is to introduce basic business management concepts and to provide the motivations to make these topics more relevant as they appear in later more advanced classes. We will cover six basic functional business areas: accounting, finance, marketing, operations, strategy, and managing technology & innovation. In addition to covering theory and applications, the course will use a business simulation to help students to understand how the functional areas tie together. This course is intended for MII-PS students; all other students by permission of the instructor.

49-703 Career Planning for Integrated Innovators

Fall: 6 units

This highly interactive class will work to assist students in uncovering abilities and identifying goals towards a career in product design/development. It will also look at ways to communicate the unique values MIIPS students have and align them with employer expectations. Students will then integrate those things into a career search plan. The class will alternate between lecture/presentations and coaching by experts and students presenting materials for practice and critique during class sessions. This course is intended for MII-PS students; all other students by permission of the instructor.

49-704 Integrated Innovation Institute-Seminar & Workshop Series

Fall and Spring

The Integrated Innovation Seminar & Workshop Series meets multiple times throughout the fall and spring semester. Seminars will focus on intellectual content from industry leaders in innovation and product development. Workshops will focus on skill building in key areas for integrated innovators. This course is a requirement of the Master of Integrated Innovation for Products & Services degree. The seminar & workshop schedule for each semester will be released on the first day of classes. This course is intended for MII-PS students; all other students by permission of the instructor.

49-710 Visual Processes

Fall: 6 units

Most drawing courses help to build skills around rendering the already seen or giving new visual form to the not-yet-seen. This is a course that focuses on giving visible form to the non-visible: processes, systems, actions, and relationships. This course is intended for MII-PS students; all other students by permission of the instructor.

49-711 Advanced Visual Processes

Fall: 6 units

The course will cover principles, tools and strategies for representing and contextualizing products with people and in environments. Short exercises will compliment a longer project assignment that is intended to begin with basic representations and advance students quickly to more sophisticated representations using analog drawing approaches. Select digital tools, along with low fidelity desktop modeling, will occasionally be used in support of visualization goals. This course expects that you can demonstrate a good level of basic drawing at the start. This course is intended for MII-PS students; all other students by permission of the instructor.

49-712 User Research Methods

Fall: 6 units

User Research Methods will teach the basic methods of user research, including one-on-one interviewing and ethnographic techniques. The course will cover research planning, field research, and the analysis of research findings. Although the course will focus on qualitative and primary research, the benefits of quantitative and secondary research will also be addressed. The course includes lectures and discussions, along with readings and research assignments. This course is intended for MII-PS students; all other students by permission of the instructor.

49-713 Designing for the Internet of Things

Spring: 6 units

Thermostats, locks, power sockets, and lights are all being imbued with "smarts" making them increasingly aware and responsive to their environment and users. This course will chart the emergence of the now "connected world" to explore the possibilities for future products and connected spaces. This introductory, hands-on course invites students to creating connected products without any knowledge of programming, electronics or systems. Students will be introduced to interactive connected technologies through a series of hands on exercises, collaborative projects, in depth discussions, and instructor led tutorials. Topics explored will include awareness, real time sensing and communication, embedded intelligence, and designing experiences for the internet of things. By the end of this course, students will be familiar with the core skills, the considerations involved and design process required to build a connected system. Students will also apply this learning in collaborative groups to realize a prototype-connected product. This course is intended for MII-PS students; all other students by permission of the instructor.

49-714 Visualization in Design

Spring: 6 units

The course will primarily focus on digital creation and communication methods for products, related screen based information, and contextualizing products in environments. Short exercises are intended to explore a range of communication options and presentation strategies to create compelling presentations. Textbooks are not required however modest cost for software, and quality color print outs are to be expected. This course is intended for MII-PS students; all other students by permission of the instructor.

49-720 Product & Brand Management

Spring: 6 units

In this course, you will progress through a series of roles, from product assistant to group product manager/marketing VP, that give you the opportunity to experience what it is like to do product and brand management. Through interactive lecture, case discussions and assignments, you will learn how to make strategic and tactical decisions, and to deal with market and internal situations that typically face product managers. The course will have an emphasis on consumer marketing, but will also address aspects of business-to-business marketing in preparing you to manage products and brand value. This course is intended for MII-PS students; all other students by permission of the instructor.

49-730 Design for Manufacture

Fall: 6 units

This course reviews manufacturing processes, the upstream implications on the overall design process (Design for Manufacture), and the downstream effects on assembly and recyclability, robustness and quality, platform design, maintenance and safety, economics and costing, and lean manufacturing. The class will study basic fundamentals in each of these areas and how they affect design decisions. This course is offered as first of two sequenced courses, 49-731, Design for the Environment is offered in Mini 2. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.

49-731 Design for the Environment

Fall: 6 units

This course explores environmental issues and the necessary consideration on the design and manufacture of sustainable products. Life cycle analysis and other impact measures are explored to guide practical DFE approaches. A major project, that includes sustainability and manufacturing, ties together concepts from design for the environment and design for manufacturing (covered in the course DFM). This course is offered as the second of two sequenced courses, 49-730, Design for Manufacture is offered in Mini 1. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.
Prerequisite: 49-730

49-740 Integrated Product Development Methods

Fall: 6 units

This course is an introduction to the Integrated Product Development (IPD) methods and the curriculum in the MII-PS program. This mini will cover methods for the first three phases of the IPD method: Identifying opportunities for new products and services; understanding those opportunities including stakeholder research and product value propositions, as well as competitive analysis; and conceptualizing opportunity solutions that meet the value proposition. This course will combine lecture, project and team skills. This course is intended for MII-PS students; all other students by permission of the instructor.

49-741 Integrated Product Development Capstone

Spring: 12 units

The IPD course focuses on team-based integrated product development among engineering, business, and design disciplines. The semester course consists of four modules including identifying, understanding, conceptualizing and introducing a product opportunity. Interdisciplinary teams of students in engineering, business, and industrial design learn methods to research the needs, wants and desires of a market opportunity, define product specifications, conceptualize products to meet the users' needs and desires and refine the most promising concept. The result is a resolved form, functional design, and marketing plan. The course also focuses on communication of the project through multiple presentations and reports. This course is intended for MII-PS students; all other students by permission of the instructor.

Prerequisite: 49-740

49-748 SPECIAL TOPICS: Integrated Innovation Institute

Intermittent: 6 units

Section A2: Designing for Seniors in the Information Age Technology has provided tremendous advantages for today's seniors: programmable medication management systems, emergency alert devices with GPS, and senior-friendly communication devices (computers and cell phones). However, it has also expanded the gap, between those who are 'keeping up with progress' and those who are not. Many seniors find themselves on the other side of the digital divide. This course will look at the unique issues associated older adults and how technology and design may be used to create products for their specific needs and facilitate ongoing engagement and re-engagement of older adults within society. Using a human-centered "design thinking" processes, we will seek to identify opportunities, assess problems, prioritize needs, and clarify potential design solutions utilizing both hardware and/or software.

Course Website: <http://www.cmu.edu/integrated-innovation/mii-ps/index.html>**49-749 Independent Study**

Fall and Spring

This independent study is designed to give students an opportunity to explore pertinent subjects through faculty directed reading or research. Variable hrs. Once you and the faculty have agreed upon the independent study, send the independent study form to the manager of Integrated Innovation Institute for enrollment. Restricted to only MII-PS students.

49-750 Software Product Definition

Fall: 12 units

Students develop and refine a compelling and realistic vision for a new product. They learn to understand user and customer needs, to document those needs, and to envision creative solutions.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>**49-751 Requirements Analysis**

Fall: 12 units

Project teams analyze, document, and plan the management of functional, technical, and business requirements for a software system and then create a product release strategy. Prerequisites: Admission to the Silicon Valley MS Software Management program and Software Product Definition (49750).
Prerequisite: 49-750

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-752 Product Definition and Validation

Fall: 12 units

Students learn techniques for envisioning creative solutions to real problems. They develop and refine a compelling and realistic vision for a new product. They practice techniques to understand and validate user and customer needs, and to identify market opportunities. They analyze, document, and plan the management of functional, technical, and business requirements for a software system and then develop a product release strategy.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-760 Foundations of Software Management

Fall: 12 units

Students apply fundamental methods, models, and frameworks to assess real software companies from a variety of perspectives - marketing, strategy, finance, operations - to understand how businesses organize and make decisions. Working individually and in groups, students develop skills for managing teams and employee performance. Students practice personal leadership.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-761 Elements of Software Management

Fall: 12 units

Through seminar discussions and individual investigation, students assess real software businesses from marketing, business strategy, financial, and overall business perspectives, applying fundamental methods, models, and frameworks.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-762 Software Product Strategy

Spring: 12 units

Students analyze market opportunities for a software product, evaluate its technical feasibility, then expand the product definition and create a product roadmap. Prerequisites: Admission to the Silicon Valley Software Management program and Requirements Analysis (49751).

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-763 The Business of Software

Spring: 12 units

Project teams develop a complete business plan for a software product, including revenue and expense models, as well as sales, marketing, and support mechanisms to define the structure of a successful software business.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-764 Entrepreneurial Finance I

Summer: 12 units

Contains a short introduction to accounting and finance fundamentals. The objective is to provide the student with the basic tools necessary to convert operating, capital, and marketing plans into a set of financial projections in the form of pro forma financial statements. For students taking 49765 the pro forma financials they use in class will be for their start-ups. The statements will include the Balance Sheet, the Profit & Loss Statement and the Cash Flow Statement.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-765 Entrepreneurial Finance II

Summer: 12 units

Examines the sources of finance for early and mid-stage companies. The course seeks to blend finance and economics to help entrepreneurs to understand; (1) the relationship between venture finance and evaluation of business risk and (2) the importance of pro forma financials in the process of valuing and raising funds for start-ups. The objective is for students to acquire a range of business understanding and skills by building a case for financing their start-up. Teams will build a VC pitch for their start-up and present their start-up to an audience of students and faculty. PRE-REQUISITE: 49-763
Prerequisite: 49-763

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-766 Agile Marketing for High Tech Innovation

Summer: 12 units

Agile Marketing for High-Tech Innovations will cover how to formulate marketing strategies that lead to successful products. It will include how marketing strategies are adapted for high tech innovations and products including addressing strategic market planning, functional expectations and tactical considerations when using marketing tools. Topics include: strategic market planning, market orientation, types of alliances needed for moving from innovation to product acceptance, understanding high-tech customers, product distribution options, technology/product management considerations for marketing effectively, pricing, marketing communications, breakthrough versus incremental innovation marketing and measuring marketing effectiveness.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-767 Organizational Behavior for High Tech Knowledge Industry

Summer: 12 units

Using innovative conceptual frameworks, students learn the fundamentals of organizational behavior as it relates to the unique challenges of high tech enterprises, concluding with a team project focused on a specific organizational problem for a selected company.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-770 Metrics for Software Managers

Fall: 12 units

This course is part of the MSSM curriculum. Priority enrollment for the course will go to students in the SM degree. Students outside of the Integrated Innovation Institute can register if seats are available or per instructor's permission.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-771 Process and Project Management

Spring: 12 units

Students define the optimal software development method for a given project, by identifying a set of Agile, Lean and/or disciplined practices suited for the project's specific needs. They also develop project's estimates and multilevel plans based on their recommended method. Prerequisites: Foundations of Software Engineering (18652) or Metrics for Software Managers (49770) or consent of instructor.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-772 Managing Software Professionals

Summer: 12 units

Students, working individually and in teams, develop skills for reviewing and managing employee performance, making hiring and firing decisions, and creating a productive work environment to support a distributed software development project. Communication styles, conflict resolution and negotiation skills are incorporated.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-773 Avoiding Software Project Failures

Summer: 12 units

Students examine several case studies, through written reports and presentations, of failed software projects to understand costly mistakes and their root causes.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-780 Human Computer Interaction

Summer: 6 units

An introduction to the field of Human Computer Interaction. The user interface and experience of a system, to a large measure, is perceived by the user as 'the system'. Innate human capabilities are discussed to understand how to make appropriate decision in designing user interfaces.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-781 Data Analytics

Summer: 6 units

An introduction to the field of Human Computer Interaction. The user interface and experience of a system, to a large measure, is perceived by the user as 'the system'. Innate human capabilities are discussed to understand how to make appropriate decision in designing user interfaces.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-782 Open Source Software

Summer: 12 units

This elective is designed to yield student proficiency regarding contemporary thinking and fundamental skills regarding Open Source Software. Emphasis is on understanding the impact of open source software on the software industry, including licensing and commercialization issues, corporate software evaluation techniques, and business models. Students install and use open source software (Linux, OpenOffice, Firefox, etc.) and work in teams in a problem-based seminar/workshop format. Team projects focus on creating evaluation criteria for specific categories of software, followed by evaluating open source software components according to the Business Readiness Rating framework. Team projects will be supplemented by recommended readings and presentations by invited outside speakers.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-783 Introduction to Cloud Computing

Summer: 12 units

This class is designed to familiarize you with the state of the art in cloud computing. The emphasis in the elective is divided between technical and business aspects of cloud computing. On the technical side, you will study mechanisms for development in the cloud, cloud deployment of applications, data storage, security, and more. On the business side, you will study how organizations are migrating applications to the cloud, as well as business models for vendors of cloud computing services and hosted application providers. We'll explore the practicality of moving all of your computing to the cloud. You will use two or more different cloud-based hosting services, and work to deploy at least one application in the cloud. (In some cases, you can do this without writing any code.) The class will include participation from guests involved in cloud computing businesses. You will work on a class project where you will be able to explore, individually or in a small group, a cloud computing topic of particular interest to you.

Course Website: <http://www.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-790 Software Management Independent Study

Intermittent

Working with the faculty, realize that the faculty are most interested in Independent Study projects that further their own research goals. You may not be successful on your first inquiry, so please be patient. We want you to have a good Independent Study experience, so faculty are encouraged to say "no" if they don't have the cycles to mentor a project. Once you and the faculty have agreed upon the independent study, send the independent study form to the director of your program.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-791 Software Management Capstone Project

Intermittent

Student teams continue work on their product or business idea. Student teams may refine or rework ideas, or continue to extend the work started in previous semesters. A plan, including milestones and deliverables, which is developed by the team must be submitted to and approved by the faculty advisor at the start of this course.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-792 Software Management Practicum

Intermittent

The practicum involves application of the SM program concepts in an actual business environment. Acting as consultants to one or more customers, student teams must scope a project; develop a project plan and detailed statement of work. Practicum topics are typically proposed by outside companies, which are looking to work with our students, but there are other options available as well. Students must demonstrate all deliverables to the customer(s), whose assessment of the work is a major component of the grade. More than a simple internship, the practicum involves real responsibility, teamwork, accountability, and rigor.

Course Website: <http://cms-staging.andrew.cmu.edu/integrated-innovation/ms-sm/courses/index.html>

49-793 Practical Training in Software Management

Summer

This course is for SM students who are pursuing an internship. Internships work is conducted on-site at local software companies. Special permission is required to be enrolled in this course, therefore, eligible students should contact the program director.

49-800 Commercializing IP

Fall: 12 units

This course focuses on product innovation based on emerging technologies that are ready for commercialization and technology transfer, but have not moved beyond the "research lab". The course will follow a rigorous product innovation process that begins with identifying feasible commercial opportunities, understanding the needs of potential customers and other stakeholders, and developing prototypes that showcase the product concept. The course entails understanding new technologies, conducting customer research, applying product innovation methods, and assessing initial business execution steps. Students enrolled in this course may follow into 49-801, Enterprise Innovation in the spring term. The goal is to focus on an execution plan and turn this into a viable product. In 2014/15, the technologies were based on 4 CMU research areas ready for tech transfer. This course is offered by CIT and the Integrated Innovation Institute. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.

49-801 Enterprise Innovation

Spring

This course is about how business enterprises are being re-invented for today's digital era. Many firms are approaching a critical inflection point. The combined impacts of technology and globalization have revolutionized the way we operate. Software is transforming the way companies innovate; how they interact with customers and ecosystem partners, the way they collaborate and communicate, how they access and distribute information, and how they co-ordinate and control. Traditional approaches that assume "stability", have given way to "dynamic" recipes. The new imperative is to swiftly navigate changing realities. Flexibility, versatility and the capacity to quickly adapt to evolving situations have become the critical challenges. The course is based on the new edition of Prof. Evans' book "Super-Flexibility for Knowledge Enterprises" (co-authored with Prof. Bahrami from Haas School of Business, UC Berkeley). Specifically, we will focus on the new rules of "super-flexibility" needed for continuous recalibration and adaptation. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor. **Students enrolled for 24 units are required to complete second project.

Prerequisite: 49-800

49-802 Innovation & Entrepreneurship I

Fall: 6 units

This course focuses on entrepreneurship and innovation from the vantage point of high-tech companies in Silicon Valley. We will explore these topics in the context of the Creation Phase - focusing on founding a new start-up and raising seed funding; and the Scaling Phase - focusing on growing a venture where startups typically undergo "B", and "C" rounds of funding; We will examine common mistakes and misconceptions in starting a new entrepreneurial business, and meet entrepreneurs, angel investors, and venture capitalists from Silicon Valley to learn, first hand, the challenges of conceiving, creating, and growing a new venture. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.

49-803 Innovation & Entrepreneurship II

Fall: 6 units

In the second part of the I&E course, our focus will be on the Consolidation Phase ? when growing ventures evolve into established global corporations. We will examine critical pain points facing this group of companies, the impact of organizational complexity, the challenge of managing a multi-business enterprise, and expanding the global footprint. This is the phase when technology companies find it more challenging to innovate and often shift their growth focus to searching for acquisitions. Invited guests will share their experiences and lessons learned, and give us a first-hand perspective on realities facing this critical group of innovative companies. Prereq: 49802, Innovation and Entrepreneurship I, MI-PS, MS-SM student status or permission of the instructor.

49-804 The Leadership Challenge

Spring: 6 units

This course studies the emerging contexts for leadership - key attributes and skills, key development points, and key actions. Leadership will be discussed in changing contexts such as agile/lean environments, emerging technology such as mobility, big data, and global issues. Other topics include decision making under uncertainty, leadership and followership, acting as a connector in an ecosystem. A leader is someone who will take you somewhere that you didn't think you could go; what does this mean for teams, businesses and you personally? There will be key readings, case studies, and a retrospective. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.

Language Technologies Institute Courses

11-344 Machine Learning in Practice

Fall: 12 units

Machine Learning is concerned with computer programs that enable the behavior of a computer to be learned from examples or experience rather than dictated through rules written by hand. It has practical value in many application areas of computer science such as on-line communities and digital libraries. This class is meant to teach the practical side of machine learning for applications, such as mining newsgroup data or building adaptive user interfaces. The emphasis will be on learning the process of applying machine learning effectively to a variety of problems rather than emphasizing an understanding of the theory behind what makes machine learning work. This course does not assume any prior exposure to machine learning theory or practice. In the first 2/3 of the course, we will cover a wide range of learning algorithms that can be applied to a variety of problems. In particular, we will cover topics such as decision trees, rule based classification, support vector machines, Bayesian networks, and clustering. In the final third of the class, we will go into more depth on one application area, namely the application of machine learning to problems involving text processing, such as information retrieval or text categorization.

11-411 Natural Language Processing

Spring: 12 units

This course will introduce students to the highly interdisciplinary area of Artificial Intelligence known alternately as Natural Language Processing (NLP) and Computational Linguistics. The course aims to cover the techniques used today in software that does useful things with text in human languages like English and Chinese. Applications of NLP include automatic translation between languages, extraction and summarization of information in documents, question answering and dialog systems, and conversational agents. This course will focus on core representations and algorithms, with some time spent on real-world applications. Because modern NLP relies so heavily on Machine Learning, we'll cover the basics of discrete classification and probabilistic modeling as we go. Good computational linguists also know about Linguistics, so topics in linguistics (phonology, morphology, and syntax) will be covered when fitting. From a software engineering perspective, there will be an emphasis on rapid prototyping, a useful skill in many other areas of Computer Science. In particular, we will introduce some high-level languages (e.g., regular expressions and Dyna) and some scripting languages (e.g., Python and Perl) that can greatly simplify prototype implementation.
Prerequisite: 15-122

11-441 Machine Learning for Text Mining

Spring: 9 units

This course provides a comprehensive introduction to the theory and implementation of algorithms for organizing and searching large text collections. The first half of the course studies text search engines for enterprise and Web environments; the open-source Indri search engine is used as a working example. The second half studies text mining techniques such as clustering, categorization, and information extraction. Programming assignments give hands-on experience with document ranking algorithms, categorizing documents into browsing hierarchies, and related topics.

11-492 Speech Processing

Fall: 12 units

to be determined by the department.

11-617 Language Technologies for Computer Assisted Language Learning

Spring: 12 units

This course studies the design and implementation of CALL systems that use Language Technologies such as Speech Synthesis and Recognition, Machine Translation, and Information Retrieval. After a short history of CALL/LT, students will learn where language technologies (LT) can be used to aid in language learning. From there, the course will explore the specifics of designing software that must interface with a language technology. For each LT, we will explore: what information does the LT require, what type of output does the LT send to the CALL interface, what are the limits of the LT that the CALL designer must deal with, what are the real time constraints, what type of training does the LT require. The goal of the course is to familiarize the student with existing systems that use LT assessment of CALL/LT software the limitations imposed by the LT designing CALL/LT software Grading criteria: several short quizzes term project: production of a small CALL/LT system, verbal presentation and written documentation of design of the software

Course Website: <http://www.lti.cs.cmu.edu/Courses/11-717-desc.htm>**11-630 MCDS Practicum Internship**

Fall

The MCDS Practicum course is used for recording CDS students summer internship units that are in the Analytics track of the program. Section A is used for 7-month internship opportunities Section B is used for Returning Fall Analytic students who DO NOT attain a 7-mo Internship. Section R is used to record MCDS students Internship Requirements

11-696 MIIS Capstone Planning Seminar

Spring: 6 units

The MIIS Capstone Planning Seminar prepares students to complete the MIIS Capstone Project in the following semester. Students are organized into teams that will work together to complete the capstone project. They define project goals, requirements, success metrics, and deliverables; and they identify and acquires data, software, and other resources required for successful completion of the project. The planning seminar must be completed in the semester prior to taking the capstone project.

11-697 MIIS Capstone Project

Spring: 6 units

to be determined

11-711 Algorithms for NLP

All Semesters: 12 units

Algorithms for NLP is an introductory graduate-level course on the computational properties of natural languages and the fundamental algorithms for processing natural languages. The course will provide an in-depth presentation of the major algorithms used in NLP, including Lexical, Morphological, Syntactic and Semantic analysis, with the primary focus on parsing algorithms and their analysis.

11-716 Graduate Seminar on Dialog Processing

All Semesters: 6 units

Dialog systems and processes are becoming an increasingly vital area of interest both in research and in practical applications. The purpose of this course will be to examine, in a structured way, the literature in this area as well as learn about ongoing work. The course will cover traditional approaches to the problem, as exemplified by the work of Grosz and Sidner, as well as more recent work in dialog, discourse and evaluation, including statistical approaches to problems in the field. We will select several papers on a particular topic to read each week. While everyone will do all readings, a presenter will be assigned to overview the paper and lead the discussion. On occasion, a researcher may be invited to present their own work in detail and discuss it with the group. A student or researcher taking part in the seminar will come away with a solid knowledge of classic work on dialog, as well as familiarity with ongoing trends.

11-721 Grammars and Lexicons

All Semesters: 12 units

Grammars and Lexicons is an introductory graduate course on linguistic data analysis and theory, focusing on methodologies that are suitable for computational implementations. The course covers major syntactic and morphological phenomena in a variety of languages. The emphasis will be on examining both the diversity of linguistic structures and the constraints on variation across languages. Students will be expected to develop and defend analyses of data, capturing linguistic generalizations and making correct predictions within and across languages. The goal is for students to become familiar with the range of phenomena that occur in human languages so that they can generalize the insights into the design of computational systems. The theoretical framework for syntactic and lexical analysis will be Lexical Functional Grammar. Grades will be based on problem sets and take-home exams.

11-722 Grammar Formalisms

Intermittent: 12 units

The goal of this course is to familiarize students with grammar formalisms that are commonly used for research in computational linguistics, language technologies, and linguistics. We hope to have students from a variety of disciplines (linguistics, computer science, psychology, modern languages, philosophy) in order to cover a broad perspective in class discussions. Comparison of formalisms will lead to a deeper understanding of human language and natural language processing algorithms. The formalisms will include: Head Driven Phrase Structure Grammar, Lexical Functional Grammar, Tree Adjoining Grammar and Categorical Grammar. If time permits, we will cover Penn Treebank, dependency grammar, and Construction Grammar. We will cover the treatment of basic syntactic and semantic phenomena in each formalism, and will also discuss algorithms for parsing and generating sentences for each formalism. If time permits, we may discuss formal language theory and generative capacity. The course is taught jointly by the following faculty of the Language Technologies Institute: Alan Black Alon Lavie Lori Levin (main coordinator)

11-731 Machine Translation

Spring: 12 units

Instructors: Chris Dyer (leader), Alon Lavie. Prerequisites: 11-711 "Algorithms for NLP" or equivalent background is recommended. Course Description: Machine Translation is an introductory graduate-level course surveying the primary approaches and methods for developing modern state-of-the-art automated language translation systems. The main objectives of the course are: Obtain a basic understanding of modern MT systems and MT-related issues. Learn about theory and approaches in Machine Translation and implement the main components of statistical MT systems.

Course Website: <http://www.lti.cs.cmu.edu/Courses/11-731-desc.html>**11-741 Machine Learning for Text Mining**

Spring: 12 units

This course studies the theory, design, and implementation of text-based information systems. The Information Retrieval core components of the course include statistical characteristics of text, representation of information needs and documents, several important retrieval models (Boolean, vector space, probabilistic, inference net, language modeling), clustering algorithms, automatic text categorization, and experimental evaluation. The software architecture components include design and implementation of high-capacity text retrieval and text filtering systems. A variety of current research topics are also covered, including cross-lingual retrieval, document summarization, machine learning, topic detection and tracking, and multi-media retrieval. Prerequisites: Programming and data-structures at the level of 15-212 or higher. Algorithms comparable to the undergraduate CS algorithms course (15-451) or higher. Basic linear algebra (21-241 or 21-341). Basic statistics (36-202) or higher.

Course Website: <http://www.lti.cs.cmu.edu/Courses/11-741-desc.html>**11-751 Speech Recognition and Understanding**

All Semesters: 12 units

The technology to allow humans to communicate by speech with machines or by which machines can understand when humans communicate with each other is rapidly maturing. This course provides an introduction to the theoretical tools as well as the experimental practice that has made the field what it is today. We will cover theoretical foundations, essential algorithms, major approaches, experimental strategies and current state-of-the-art systems and will introduce the participants to ongoing work in representation, algorithms and interface design. This course is suitable for graduate students with some background in computer science and electrical engineering, as well as for advanced undergraduates. Prerequisites: Sound mathematical background, knowledge of basic statistics, good computing skills. No prior experience with speech recognition is necessary. This course is primarily for graduate students in LTI, CS, Robotics, ECE, Psychology, or Computational Linguistics. Others by prior permission of instructor.

11-752 Speech II: Phonetics, Prosody, Perception and Synthesis

Spring: 12 units

The goal of the course is to give the student basic knowledge from several fields that is necessary in order to pursue research in automatic speech processing. The course will begin with a study of the acoustic content of the speech signal. The students will use the spectrographic display to examine the signal and discover its variable properties. Phones in increasingly larger contexts will be studied with the goal of understanding coarticulation. Phonological rules will be studied as a contextual aid in understanding the spectrographic display. The spectrogram will then serve as a first introduction to the basic elements of prosody. Other displays will then be used to study the three parts of prosody: amplitude, duration, and pitch. Building on these three elements, the student will then examine how the three interact in careful and spontaneous speech. Next, the students will explore perception. Topics covered will be: physical aspects of perception, psychological aspects of perception, testing perception processes, practical applications of knowledge about perception. The second part of this course will cover all aspects of speech synthesis. Students need only have a basic knowledge of speech and language processing. Some degree of programming and statistical modelling will be beneficial, but not required. Taught every other year

Course Website: <http://www.lti.cs.cmu.edu/Courses/11-752-desc.html>**11-761 Language and Statistics**

Spring: 12 units

Language technologies (search, text mining, information retrieval, speech recognition, machine translation, question answering, biological sequence analysis...) are at the forefront of this century's information revolution. In addition to their use of machine learning, these technologies rely centrally on classic statistical estimation techniques. Yet most CS and engineering undergraduate programs do not prepare students in this area beyond an introductory prob&stats course. This course is designed to plug this hole. The goal of "Language and Statistics" is to ground the data-driven techniques used in language technologies in sound statistical methodology. We start by formulating various language technology problems in both an information theoretic framework (the source-channel paradigm) and a Bayesian framework (the Bayes classifier). We then discuss the statistical properties of words, sentences, documents and whole languages, and the computational formalisms used to represent language. These discussions naturally lead to specific concepts in statistical estimation. Topics include: Zipf's distribution and type-token curves; point estimators, Maximum Likelihood estimation, bias and variance, sparseness, smoothing and clustering; interpolation, shrinkage, and backoff; entropy, cross entropy and mutual information; decision tree models applied to language; latent variable models and the EM algorithm; hidden Markov models; exponential models and maximum entropy; semantic modeling and dimensionality reduction; probabilistic context-free grammars and syntactic language models. The course is designed for LTI & SCS graduate students, but others are welcome. CS UG upperclassmen who've taken it have done well, though they found it challenging. The 11-661 version does not require the course project. Prerequisites: Strong quantitative aptitude. Comfort with basic UG-level probability. Some programming skill.

Course Website: <http://www.cs.cmu.edu/~roni/11761/>**11-762 Language and Statistics II**

Fall: 12 units

This course will cover modern empirical methods in natural language processing. It is designed for language technologies students who want to understand statistical methodology in the language domain, and for machine learning students who want to know about current problems and solutions in text processing. Students will, upon completion, understand how statistical modeling and learning can be applied to text, be able to develop and apply new statistical models for problems in their own research, and be able to critically read papers from the major related conferences (EMNLP and ACL). A recurring theme will be the tradeoffs between computational cost, mathematical elegance, and applicability to real problems. The course will be organized around methods, with concrete tasks introduced throughout. The course is designed for SCS graduate students. Prerequisite: Language and Statistics (11-761) or permission of the instructor. Recommended: Algorithms for Natural Language Processing (11-711), Machine Learning (15-681, 15-781, or 11-746). Prerequisite: 11-761

11-792 Intelligent Information Systems Project

Spring: 12 units

The Software Engineering for IS sequence combines classroom material and assignments in the fundamentals of software engineering (11-791) with a self-paced, faculty-supervised directed project (11-792). The two courses cover all elements of project design, implementation, evaluation, and documentation. Students may elect to take only 11-791; however, if both parts are taken, they should be taken in proper sequence. Prerequisite: 11-791. The course is required for VLIS students.

Prerequisites: 11-791 or 15-393

Course Website: <http://www.lti.cs.cmu.edu/Courses/11-791-desc.html>**11-927 MIIIS Capstone Project**

Fall: 36 units

The capstone project course is a group-oriented demonstration of student skill in one or more areas covered by the degree. Typically the result of the capstone project is a major software application. The capstone project course consists of two components. The classroom component guides students in project planning, team management, development of requirements and design specifications, and software tools for managing group-oriented projects. The lab component provides project-specific technical guidance and expertise, for example in the development of a question answering system, dialog, or sentiment analysis application. Thus, each project receives two types of supervision, often from two separate members of the faculty.

MCS Interdisciplinary Courses

38-101 EUREKA!: Discovery and Its Impact

Fall: 6 units

The MCS first-year seminar "EUREKA: Discovery and Its Impact" will equip new students with foundational knowledge, skills and perspectives that will support their development as emerging scientists. During the seminar, students will be presented with opportunities and experiences designed to help them frame how the MCS curriculum aspires to shape their evolving identities in the areas of scholar, person, professional and citizen, while also engendering a sense of excitement about science and scientific inquiry. The seminar will offer information and strategies that are employed both by successful students and by successful scientists in optimizing their approach to work and life, with a key focus on areas such as cognitive learning skills, research, teamwork, goal setting, time management, innovation, community engagement, ethics, resources and assessment. Additionally, the seminar will introduce first-year students to the learning outcomes and requirements associated with the MCS core curriculum, with a particular emphasis on the self-directed ENGAGE courses and the role of the e-portfolio system in documenting and framing student growth and development.

38-110 ENGAGE in Service

Fall and Spring: 1 unit

Engage in Service is a 1 unit course (9 hours of work, minimum requirement for a passing grade) designed to promote MCS students' direct engagement with community development and service learning. To fulfill this requirement, students must engage in a minimum of 9 hours of work devoted to a non-profit organization or organizations of their choice. Students may complete the requirements anytime during their undergraduate years, but must register for the class during the semester that they intend to complete it, no later than their penultimate semester. Coursework includes documentation of service via completion of a form for each eligible activity that includes a time log, a description of the activity, the name and contact information for their supervisor and the supervisor's signature. In addition, during the last semester of the project/course students will prepare a reflective paper on the lessons learned from their immersion in the organization(s) and its (their) work. No pay or other compensation (including academic credit) can be received for the work performed.

38-210 BIOSSS: Biotechnology Impacting Our Selves, Societies and Spheres

Intermittent: 6 units

The biotechnology era has begun and its impact is being felt at multiple levels that range from individual effects to global concerns. Vocabularies are expanding to include words such as stem cells, genomes, SARS and anthrax while hearts and minds are grappling with related issues such as human cloning, DNA profiling, epidemic control and bioterrorism. Emerging infectious diseases have no respect for national boundaries and challenge our knowledge, resources and personal well-being. Understanding and responding to such personal, societal and global challenges requires a level of scientific literacy currently deficient in much of the general citizenry. In addition, scientists of the future must be able to apply their disciplinary knowledge within the context of relevant ethical, legal and societal influences. "B.I.O.S.3: Biotechnology Impacting Our Selves, Societies and Sphere is a course on biotechnology literacy and decision making in a global context. The guiding framework of the course curriculum design is centered on an application of the principles of the central dogma of biotechnology. The approach can be described as the "transcription" of core knowledge into context followed by the "translation" of that knowledge into global perspective and personal action. The course will involve the development and implementation of core topic modules. The first module piloted will focus on HIV/AIDS.

38-220 ENGAGE in the Arts

Fall and Spring: 2 units

Engage in the Arts is part of Mellon College of Science's Core Curriculum. In this 2 unit full-semester course, students will broaden their knowledge of the fine arts, extend their global and cultural awareness, and facilitate the further development of their self-identity. Coursework requires that students attend 8 distinct arts events, 2 of which must engage with a culture different from one's personal cultural background. In choosing events, students should be imbued with an attitude of openness to new ideas and a willingness to try something new. The course requires students to share, reflect, and document their participation in a variety of arts events by engaging with classmates and instructors through MyCORE, where they can upload coursework and find postings for events. Coursework can be completed at any time during students' undergraduate years, but they must register for the class during the semester that they intend to complete it.

38-230 ENGAGE in Wellness: Looking Inward

Spring: 1 unit

Engage in Wellness: Looking Inward is a 1-unit mini-course that MCS students will enroll in the spring of the sophomore year, designed to give students a holistic understanding of their own personal wellness. The course is structured around the concept of a Wellness Wheel, a model for personal wellness that is used to describe the various areas that students should reflect upon when describing, and ultimately improving, their overall wellness. The MCS Wellness Wheel has nine components: intellectual, physical, emotional, spiritual, environmental, institutional or community, financial, social, and occupational health. During this first course, taken in the third mini of the sophomore year, students will select one of three areas on which to focus: intellectual, emotional or physical health. They will be asked to engage in a recursive, reflective process to assess their own level of wellness in this area, develop short-term goals for the next year and a statement of a longer-term goal in this area, identify possible resources and then choose activities that promote this aspect of wellness. Students should expect to devote 9-14 hours to the development and articulation of their plan in order to earn a passing grade. These hours are tied to completion of the requested assessments and not to the activities students elect to pursue in fulfillment of their wellness plan.

38-301 MCS Junior Seminar

Spring: 6 units

The MCS Seminar will leverage students' deepening disciplinary perspective in service of the development of competencies, skills, and perspectives that are necessary to achieve professional excellence in today's society. The course will use traditional career development activities, such as interviewing, resume writing, and networking, as a starting point for students to begin the process of reflecting on, and preparing for, their impending transitions into professional life. From there, the course will seek to expand students' conceptualization of the scientific workplace by exploring the interplay of science, innovation, public policy, entrepreneurship and business in professional settings. The Seminar will also engage students in global examples of the reciprocal relationships among science, technology, political forces, societal contexts and environmental issues. Students will refine their multidisciplinary teamwork and communication skills via small group projects focusing on the aforementioned course themes. Finally, the Seminar will include an audit of progress toward completion of the MCS core requirements in the following year.

38-330 ENGAGE in Wellness: Looking Outward

Fall: 1 unit

Engage in Wellness: Looking Outward is a 1-unit mini-course that MCS students will enroll in the fall of the junior year, designed to give students a holistic understanding of their own personal wellness. The course is structured around the concept of a Wellness Wheel, a model for personal wellness that is used to describe the various areas that students should reflect upon when describing, and ultimately improving, their overall wellness. The MCS Wellness Wheel has nine components: intellectual, physical, emotional, spiritual, environmental, institutional or community, financial, social, and occupational health. During this second course, taken in the second mini of the junior year, students will select one of three areas on which to focus: spiritual, environmental and institutional or community health. They will be asked to engage in a recursive, reflective process to assess their own level of wellness in this area, develop short-term goals for the next year and a statement of a longer-term goal in this area, identify possible resources and then choose activities that promote this aspect of wellness. Students should expect to devote 9-14 hours to the development and articulation of their plan in order to earn a passing grade. These hours are tied to completion of the requested assessments and not to the activities students elect to pursue in fulfillment of their wellness plan.

38-411 The Science and Mathematics of Art

Intermittent: 6 units

This interdisciplinary course will provide a view of the application of mathematical and scientific knowledge in the creation, analysis, conservation, restoration and preservation of art work. The course will combine science and art history lectures with field work to Museums and Art Galleries. Students from diverse science and mathematics backgrounds will be exposed to the methods, demands, and aims of other technical and non-technical disciplines. They will be challenged to consider and communicate how their own discipline relates to- and enables the development of art and to identify synergetic relationships between different areas of human endeavor. Students will collaboratively design and carry out final projects which combine research and creative work; these projects will be designed such that they can be used in local Museums for public outreach. A series of researchers and artists who work at the boundary between science and art will give guest lectures.

Prerequisites: 03-115 or 03-124 or 03-343 or 09-122 or 09-221 or 33-104 or 21-270 or 21-292 or 21-369 or 33-100 or 21-257

38-430 ENGAGE in Wellness: Looking Forward

Fall: 1 unit

Engage in Wellness: Looking Forward is a 1-unit mini-course that MCS students will enroll in the fall of the senior year, designed to give students a holistic understanding of their own personal wellness. The course is structured around the concept of a Wellness Wheel, a model for personal wellness that is used to describe the various areas that students should reflect upon when describing, and ultimately improving, their overall wellness. The MCS Wellness Wheel has nine components: intellectual, physical, emotional, spiritual, environmental, institutional or community, financial, social, and occupational health. During this third course, taken in the first mini of the senior year, students will select one of three areas on which to focus: financial, social and occupational health. They will be asked to engage in a recursive, reflective process to assess their own level of wellness in this area, develop short-term goals for the next year and a statement of a longer-term goal in this area, identify possible resources and then choose activities that promote this aspect of wellness. Students should expect to devote 9-14 hours to the development and articulation of their plan in order to earn a passing grade. These hours are tied to completion of the requested assessments and not to the activities students elect to pursue in fulfillment of their wellness plan.

38-709 Applied Cell and Molecular Biology

Fall: 12 units

This course will examine applications of modern cell and molecular biology, with emphasis on commercial products and processes. The course will include a basic background in the major topics that would be covered in courses on prokaryotic and eukaryotic molecular biology and molecular cell biology. The course is intended for non-specialists who seek an understanding and appreciation of fundamental concepts without the analysis of experimental detail that would support the development of concepts in a course for the specialist. The course will draw on the patent literature as a source of commercial applications of biological discoveries. Examples of the topics that might be included are: diagnostic and therapeutic monoclonal antibodies (e.g., Herceptin), therapeutic proteins (e.g., colony stimulating factors, erythropoietin, hormones), antibiotics, subunit molecular vaccines, amino acid fermentations, enzyme based processes for chemical synthesis, gene therapy, stem cells and regenerative medicine, herbicide tolerant plants, microbial diagnostics (e.g., multilocus sequence typing), transgenic animals, DNA fingerprinting.

38-710 Principles of Biotechnology

Spring: 12 units

This course is intended to provide an introduction to a set of core areas currently highlighted in the biotechnology industries. The objective is to provide the appropriate background for management level personnel to optimize their decision-making based on knowledgeable background in today's technologies. The focus will be on weekly modules of similar technologies with an introduction to technology/science behind the topic area and the applications of the technology in today's industries and markets.

38-801 Evidence Based Teaching in the Sciences

Fall and Spring: 7 units

Special Permission Only: This course is designed to prepare PhD students from science disciplines to: (1) teach effectively and efficiently as future faculty members; (2) critically read and apply peer-reviewed, STEM-based educational research; and (3) adapt approaches from the Scholarship of Teaching and Learning (SoTL) to formatively assess student learning and iteratively improve teaching and course design. Together, we will explore the research on teaching and student learning, identifying and challenging our assumptions regarding how college students learn best in science disciplines. Participants will leverage this research to cultivate a diverse toolkit of evidence-based, student-centered strategies for teaching and course design that may be applied to face-to-face, blended, or online courses, both within and across STEM disciplines. Prior teaching experience is not required, but students must have completed their first year of PhD study to enroll. This course will not prepare or license participants to teach K-12 students in Pennsylvania or elsewhere.

Machine Learning Courses

10-401 Introduction to Machine Learning

Fall and Spring: 12 units

TBA

10-601 Introduction to Machine Learning

Fall and Spring: 12 units

Machine Learning (ML) develops computer programs that automatically improve their performance through experience. This includes learning many types of tasks based on many types of experience, e.g. spotting high-risk medical patients, recognizing speech, classifying text documents, detecting credit card fraud, or driving autonomous vehicles. 10601 covers all or most of: concept learning, decision trees, neural networks, linear learning, active learning, estimation & the bias-variance tradeoff, hypothesis testing, Bayesian learning, the MDL principle, the Gibbs classifier, Naive Bayes, Bayes Nets & Graphical Models, the EM algorithm, Hidden Markov Models, K-Nearest-Neighbors and nonparametric learning, reinforcement learning, bagging, boosting and discriminative training. Grading will be based on weekly or biweekly assignments (written and/or programming), a midterm, a final exam, and possibly a project (details may vary depending on the section). 10601 is recommended for CS Seniors & Juniors, quantitative Masters students, & non-MLD PhD students. Prerequisites (strictly enforced): strong quantitative aptitude, college prob&stats course, and programming proficiency. For learning to apply ML practically & effectively, without the above prerequisites, consider 11344/05834 instead. You can evaluate your ability to take the course via a self-assessment exam at: http://www.cs.cmu.edu/~aarti/Class/10701_Spring14/Intro_ML_Self_Evaluation.pdf For section-specific information, see: Section 10601A: <https://sites.google.com/site/10601a14spring/about-the-class> Section 10601B: <http://www.cs.cmu.edu/~10601b/> Prerequisites: 15-122 and (15-151 or 21-127)

Corequisites: 36-225 or 36-217 or 21-325 or 15-359

Course Website: <https://sites.google.com/site/10601a14spring/about-the-class>

10-605 Machine Learning with Large Datasets

Spring: 12 units

Large datasets are difficult to work with for several reasons. They are difficult to visualize, and it is difficult to understand what sort of errors and biases are present in them. They are computationally expensive to process, and often the cost of learning is hard to predict - for instance, an algorithm that runs quickly in a dataset that fits in memory may be exorbitantly expensive when the dataset is too large for memory. Large datasets may also display qualitatively different behavior in terms of which learning methods produce the most accurate predictions. This course is intended to provide a student practical knowledge of, and experience with, the issues involving large datasets. Among the issues considered are: scalable learning techniques, such as streaming machine learning techniques; parallel infrastructures such as map-reduce; practical techniques for reducing the memory requirements for learning methods, such as feature hashing and Bloom filters; and techniques for analysis of programs in terms of memory, disk usage, and (for parallel methods) communication complexity. The class will include programming assignments, and a one-month short project chosen by the student. The project will be designed to compare the scalability of variant learning algorithms on datasets. An introductory course in machine learning, like 10-601 or 10-701, is a prerequisite or a co-requisite. If you plan to take this course and 10-601 concurrently please tell the instructor. The course will include several substantial programming assignments, so an additional prerequisite is 15-211, or 15-214, or comparable familiarity with Java and good programming skills. Undergraduates need permission of the instructor to enroll.

Prerequisites: 15-210 or 15-214

Corequisites: 10-701 or 10-601

Course Website: http://curtis.ml.cmu.edu/w/courses/index.php/10-605_in_Spring_2015**10-701 Introduction to Machine Learning**

Fall and Spring: 12 units

Machine learning studies the question "How can we build computer programs that automatically improve their performance through experience?" This includes learning to perform many types of tasks based on many types of experience. For example, it includes robots learning to better navigate based on experience gained by roaming their environments, medical decision aids that learn to predict which therapies work best for which diseases based on data mining of historical health records, and speech recognition systems that learn to better understand your speech based on experience listening to you. This course is designed to give PhD students a thorough grounding in the methods, mathematics and algorithms needed to do research and applications in machine learning. Students entering the class with a pre-existing working knowledge of probability, statistics and algorithms will be at an advantage, but the class has been designed so that anyone with a strong numerate background can catch up and fully participate. You can evaluate your ability to take the course via a self-assessment exam that will be made available to you after you register. If you are interested in this topic, but are not a PhD student, or are a PhD student not specializing in machine learning, you might consider the master's level course on Machine Learning, 10-601." This class may be appropriate for MS and undergrad students who are interested in the theory and algorithms behind ML. You can evaluate your ability to take the course via a self-assessment exam at: http://www.cs.cmu.edu/~aarti/Class/10701_Spring14/Intro_ML_Self_Evaluation.pdf
Course Website: <http://www.cs.cmu.edu/~epxing/Class/10701-11f/>

10-715 Advanced Introduction to Machine Learning

Fall: 12 units

The rapid improvement of sensory techniques and processor speed, and the availability of inexpensive massive digital storage, have led to a growing demand for systems that can automatically comprehend and mine massive and complex data from diverse sources. Machine Learning is becoming the primary mechanism by which information is extracted from Big Data, and a primary pillar that Artificial Intelligence is built upon. This course is designed for Ph.D. students whose primary field of study is machine learning, or who intend to make machine learning methodological research a main focus of their thesis. It will give students a thorough grounding in the algorithms, mathematics, theories, and insights needed to do in-depth research and applications in machine learning. The topics of this course will in part parallel those covered in the general graduate machine learning course (10-701), but with a greater emphasis on depth in theory and algorithms. The course will also include additional advanced topics such as RKHS and representer theory, Bayesian nonparametrics, additional material on graphical models, manifolds and spectral graph theory, reinforcement learning and online learning, etc. Students entering the class are expected to have a pre-existing strong working knowledge of algorithms, linear algebra, probability, and statistics. If you are interested in this topic, but do not have the required background or are not planning to work on a PhD thesis with machine learning as the main focus, you might consider the general graduate Machine Learning course (10-701) or the Masters-level Machine Learning course (10-601).

Course Website: <http://www.cs.cmu.edu/~epxing/Class/10715/>**10-806 Foundations of Machine Learning and Data Science**

Fall: 12 units

This course will cover fundamental topics in Machine Learning and Data Science, including powerful algorithms with provable guarantees for making sense of and generalizing from large amounts of data. The course will start by providing a basic arsenal of useful statistical and computational tools, including generalization guarantees, core algorithmic methods, and fundamental analysis models. We will examine questions such as: Under what conditions can we hope to meaningfully generalize from limited data? How can we best combine different kinds of information such as labeled and unlabeled data, leverage multiple related learning tasks, or leverage multiple types of features? What can we prove about methods for summarizing and making sense of massive datasets, especially under limited memory? We will also examine other important constraints and resources in data science including privacy, communication, and taking advantage of limited interaction. In addressing these and related questions we will make connections to statistics, algorithms, linear algebra, complexity theory, information theory, optimization, game theory, and empirical machine learning research. Topics to be covered will include:
- Fundamental measures of complexity for generalization, including VC-dimension and Rademacher complexity.
- Core algorithmic tools including boosting, regularization, and online optimization with connections to game theory.
- Spectral methods, streaming algorithms and other approaches for handling massive data.
- Foundations and algorithms for addressing important constraints or externalities such as privacy, limited memory, and communication constraints.
- Foundations for modern learning paradigms including semi-supervised learning, never-ending learning, interactive learning, and deep learning.

Course Website: <http://www.cs.cmu.edu/~ninamf/courses/806/10-806-index.htm>

Materials Science Engineering Courses

27-052 Introduction to NanoScience and Technology

Summer: 9 units

This course is offered within Carnegie Mellon's Advanced Placement Early Admissions (APEA) program. The course is primarily intended to provide an introduction to nanoscience and technology to a wide audience of students at the advanced high school to incoming freshmen level. The course goals are twofold: (1) to provide students with a holistic view of the objectives, opportunities and challenges of the emerging field of nanotechnology and (2) to sensitize students at an early stage of their career to the relevance of the connections among the traditional disciplines as a vital element to the progress in interdisciplinary areas such as nanotechnology. The course will cover: Introduction and fundamental science; Preparation of nanostructures; Characterization of nanostructures; Application examples, Social and ethical aspects of nanotechnology. Admission according to APEA guidelines.

27-100 Engineering the Materials of the Future

Fall and Spring: 12 units

Materials form the foundation for all engineering applications. Advances in materials and their processing are driving all technologies, including the broad areas of nano-, bio-, energy, and electronic (information) technology. Performance requirements for future applications require that engineers continue to design both new structures and new processing methods in order to engineer materials having improved properties. Applications such as optical communication, tissue and bone replacement, fuel cells, and information storage, to name a few, exemplify areas where new materials are required to realize many of the envisioned future technologies. This course provides an introduction to how science and engineering can be exploited to design materials for many applications. The principles behind the design and exploitation of metals, ceramics, polymers, and composites are presented using examples from everyday life, as well as from existing, new, and future technologies. A series of laboratory experiments are used as a hands-on approach to illustrating modern practices used in the processing and characterization of materials and for understanding and improving materials' properties.

Corequisites: 33-106 and 21-120

27-201 Structure of Materials

Fall: 9 units

This course covers the fundamentals of crystallography and diffraction. Topics covered include: the periodic table of the elements, bonding in different classes of materials, Bravais lattices, unit cells, directions and planes, crystal geometry computations, direct and reciprocal space, symmetry operations, point and space groups, nature of x-rays, scattering in periodic solids, Bragg's law, the structure factor, and the interpretation of experimental diffraction patterns. 24 crystal structure types of importance to various branches of materials science and engineering will be introduced. Amorphous materials, composites and polymers are also introduced. This course includes both lectures and laboratory exercises.

Prerequisite: 21-122

Corequisite: 27-100

27-202 Defects in Materials

Fall: 9 units

Defects have a fundamental influence on the properties of materials, including deformation, electrical, magnetic, optical, and chemical properties, as well as the rates of diffusion in solids. As such, by the controlling the population of intrinsic and extrinsic defects, one can tailor the properties of materials towards specific engineering applications. The objective of this course, which includes classroom and laboratory sessions, is to define approaches to quantifying the populations and properties of defects in crystals. The course will be divided into three sections: point defects, dislocations, and planar defects. The formation of point defects and their influence on diffusion, electrical, and magnetic properties will be considered. The properties and characteristics of dislocations and dislocation reactions will be presented, with a focus on the role of dislocations in deformation. The crystallography and energetics of planar defects and interfaces will also be described, with a focus on microstructural evolution at high temperatures. Time permitting, volume defects or other special topics are also discussed.

Prerequisite: 21-122

Corequisite: 27-100

27-205 Introduction to Materials Characterization

Spring: 3 units

The course introduces the modern methods of materials characterization, including characterization of microstructure and microchemistry of materials. A classroom component of the course will introduce the wide array of methods and applications of characterization techniques. Basic theory will be introduced where needed. Students will then be instructed in the use of several instruments such as AFM, SEM, and EDS, using a hands-on approach. All instruments are part of the existing lab facilities within MSE and CIT. The methods learned in this course will serve the student during several other higher level courses, such as the Senior level MSE Capstone Course (27-401).

27-210 Materials Engineering Essentials

Fall: 6 units

This course approaches professional skill holistically, having materials science and engineering students understand that being a professional includes having competencies and responsibilities that are personal, organizational and professional.

Prerequisites: 21-120 or 21-122

27-211 Structure of Materials (Minor Option)

6 units

This course is identical to 27-201, but without the 3-unit lab component.

27-212 Defects in Materials (Minor Option)

6 units

THIS IS FOR THE MSE MINOR ONLY: Defects have a fundamental influence on the properties of materials, including deformation, electrical, magnetic, optical, and chemical properties, as well as the rates of diffusion in solids. As such, by the controlling the population of intrinsic and extrinsic defects, one can tailor the properties of materials towards specific engineering applications. The objective of this course, which includes classroom and laboratory sessions, is to define approaches to quantifying the populations and properties of defects in crystals. The course will be divided into three sections: point defects, dislocations, and planar defects. The formation of point defects and their influence on diffusion, electrical, and magnetic properties will be considered. The properties and characteristics of dislocations and dislocation reactions will be presented, with a focus on the role of dislocations in deformation. The crystallography and energetics of planar defects and interfaces will also be described, with a focus on microstructural evolution at high temperatures. Time permitting, volume defects or other special topics are also discussed.

27-215 Thermodynamics of Materials

Fall: 12 units

The first half of the course will focus on the laws of thermodynamics and the inter-relations between heat, work and energy. The concept of an equilibrium state of a system will be introduced and conditions which must be satisfied for a system to be at equilibrium will be established and discussed and the concepts of activity and chemical potential introduced. The second half of the course will focus on chemical reactions, liquid and solid solutions, and relationships between the thermodynamics of solutions and binary phase diagrams.

Corequisites: 27-100 and 21-259

27-216 Transport in Materials

Spring: 9 units

This course is designed to allow the student to become familiar with the fundamental principles of heat flow, fluid flow, mass transport and reaction kinetics. In addition, the student will develop the skills and methodologies necessary to apply these principles to problems related to materials manufacture and processing. Topics will include thermal conductivity, convection, heat transfer equations, an introduction to fluid phenomena viscosity, etc., Newtons and Stokes Laws, mass momentum balances in fluids, boundary layer theory, diffusion and absolute reaction rate theory. Where appropriate, examples will be taken from problems related to the design of components and the processing of materials.

Prerequisites: 15-110 and 27-215

Corequisite: 09-105

27-217 Phase Relations and Diagrams

Spring: 12 units

Stability of structures. Hume-Rothery rules. Free energy-composition curves with applications to binary and ternary phase diagrams. Quantitative concepts of nucleation and growth with examples from solidification. Development of microstructures in various classes of phase diagram under near-equilibrium conditions. Atomic mechanisms of solid state diffusion and approach to equilibrium through diffusion.

Prerequisites: 09-105 and 27-201 and 27-215

Corequisite: 27-202

27-299 Professional Development I

Fall: 1 unit

This is a course that is designed to teach engineering business and professional skills to the MSE students. It is attended by sophomores, juniors and seniors and the courses Professional Topics I, II and III are given once per year on a three year cycle. Year 1: Work Place Skills, Leadership Skills and Teams Year 2: Project Management Year 3: Ethics, Business Planning, Lifetime Learning Although the course is not specifically designed as "metals, polymers, ceramics and composites", real world problems are used for examples and discussions. Assignments, when used, (for example, in project management or business planning) can be case studies or typical assignments a materials scientist may encounter during his/her employment.

27-301 Microstructure and Properties I

Fall: 9 units

The objective of this courses and its companion 27-302 is to convey some of the essential concepts in materials science and engineering that relate material properties (strength, magnetism, thermal expansion) to microstructure (crystal structure, dislocations structure, grain structure, precipitate structure, composite structure) in single phase materials. The relationships will be illustrated with examples of both idealized and technological materials. The course will draw upon many aspects of materials science such as defects, phase transformations etc. The course includes both lectures and laboratory exercises.

Prerequisites: 27-216 and 27-217

27-311 Polymeric Biomaterials

Spring: 9 units

This course will provide students with an introduction to polymers used in medical applications. Following a brief discussion of the physical properties of polymers and tissues, we will survey important classes of polymeric biomaterials, discussing material preparation, processing, properties and applications. Topics will include silicone elastomers, degradable hydrogels, ultra-high molecular weight polyethylene, polyurethanes, polyesters, and biopolymers such as silks and collagen. In addition, students will participate in a semester-long entrepreneurship project where they propose a new medical technology based on polymeric biomaterials. This semester we will discuss this primarily in the context of materials for wound healing applications. Student teams will perform market research on wound healing products, propose a novel bioactive dressing for wound healing applications, and identify methods for the testing and production of their product.

27-323 Powder Processing of Materials

Fall: 9 units

This course addresses the methods used in, and the principles that underlie, powder processing of metals and ceramics. Aspects of powder processing will be discussed in relation to the use of materials in engineering applications. The relationship between processing methods and materials performance in select applications will be discussed using specific materials examples including metals and ceramics. The course is broken down into three main parts: (1) understanding, selecting, and controlling powder characteristics; (2) powder handling, compaction, and forming techniques; and (3) drying, burnout, densification, sintering, and grain growth in powder compacts. Topics include chemical thermodynamics, reaction kinetics, surfaces, colloids, dispersions, process engineering, powder handling, powder compaction, shape forming, densification, and sintering. Prerequisites: 27-100 and 27-216 and 27-215 and 27-202

27-324 Introduction to Polymer Science and Engineering

Fall: 9 units

This course introduces the fundamental properties of polymer materials and the principles underlying the design as well as the engineering and manufacturing of polymer materials. The basic characteristics of macromolecules will be discussed followed by an introduction to relevant forming technologies and their significance to material performance. Technologically relevant engineering properties of polymer materials will be introduced with focus on mechanical, electrical, and optical properties. Selected case studies and design projects will introduce students to the various stages of technical product development, i.e. problem analysis, material selection and processing plan. (

27-325 Polymer Physics and Morphology

Fall: 9 units

This course introduces the fundamental concepts necessary to understand the structure of polymers in the solid state. The structure of polymers will be discussed with focus on the amorphous, crystalline and liquid-crystalline state. One aim is to provide the student intuition about the organization of polymer molecules in the solid state based on the polymer's chemical structure. Attention will be given to the phenomenon of glass transition in amorphous polymers as well as the morphology and kinetics of crystal formation in semi-crystalline polymers. The second part of the course will focus on polymer multicomponent materials. Basic concepts of lattice models will be introduced and applied to predict the phase behavior of polymer blends. A last section will focus on microdomain formation in block copolymer materials.

27-357 Introduction to Materials Selection

Spring: 6 units

The objective of this course is to teach the fundamentals of materials science as related to metals and metal alloys. The topics to be covered include crystal structure, defects, diffusion, binary phase diagrams, microstructure and processing, elastic and plastic deformation, equations of elasticity for isotropic materials, deformation of single crystal, slip systems, the tensile test, Von Mises yield criteria, strengthening mechanisms, phase transformations in steels, microstructures of steels, fracture and toughness, creep and corrosion.

27-367 Selection and Performance of Materials

Spring: 6 units

This course teaches the selection methodologies for materials and processes for satisfaction of a design goal. Topics such as performance under load, shape effects, material properties (intrinsic and as influenced by processing) are discussed and applied so as to determine the fitness of use of materials for applications. Expanded topics include economics, codes and standards, environmental and safety regulations, professional ethics and life cycle analysis where applicable. The course incorporates a project where virtual teams work to provide material selection for a specific application problem. Prerequisites: 27-100 Prerequisites: 27-100 and 27-301

27-399 Professional Development II

Fall: 1 unit

This is a course that is designed to teach engineering business and professional skills to the MSE students. It is attended by sophomores, juniors and seniors and the courses Professional Topics I, II and III are given once per year on a three year cycle. Year 1: Work Place Skills, Leadership Skills and Teams Year 2: Project Management Year 3: Ethics, Business Planning, Lifetime Learning Although the course is not specifically designed as "metals, polymers, ceramics and composites", real world problems are used for examples and discussions. Assignments, when used, (for example, in project management or business planning) can be case studies or typical assignments a materials scientist may encounter during his/her employment.

27-401 MSE Capstone Course I

Fall: 12 units

This capstone course introduces the student to the methodology used for projects and team based research as practiced in the Materials Science and Engineering workplace. This is a project course that requires the knowledge relationship among processing, structure, and performance to address an important contemporary problem in materials science and engineering. Student taking this course will work in a team environment to complete a design project to resolve scientific and engineering issues relating to materials. Topics will be selected from a list or material problems or research concepts generated from industrial or academia. All research is expected to be original, and proper scientific ethics, and methodologies are enforced for the research and reports. Team participation and communication is an important issue and the presentation and reports must be technical and professional in structure. The course requires full project management and accounting for the research being conducted. On the topic selected, the work product is a report that provides clear definition of the problem being addressed, a methodology for the research, literature review, experimentation and reporting of findings, conclusions based on findings, and recommendations for future work. Prerequisites: 27-205 and 27-367

27-402 MSE Capstone Course II

Spring: 12 units

This is the spring extension of 27-401. Teams or team members that have the industry agreement and that wish to continue their research project may do so in this course. As with 27-401, all research is expected to be original, and proper scientific ethics, and methodologies are enforced for the research and reports. Team participation and communication is an important issue and the presentation and reports must be technical and professional in structure. The course requires full project management and accounting for the research being conducted. On the topic selected, the work product is a report that provides clear definition of the problem being addressed, a methodology for the research, literature review, experimentation and reporting of findings, conclusions based on findings, and recommendations for future work. Prerequisites: 27-401 Prerequisite: 27-401

27-410 Computational Techniques in Engineering

Spring: 12 units

This course develops the methods to formulate basic engineering problems in a way that makes them amenable to computational/numerical analysis. The course will consist of three main modules: basic programming skills, discretization of ordinary and partial differential equations, and numerical methods. These modules are followed by two modules taken from a larger list: Monte Carlo-based methods, molecular dynamics methods, image analysis methods, and so on. Students will learn how to work with numerical libraries and how to compile and execute scientific code written in Fortran-90 and C++. Students will be required to work on a course project in which aspects from at least two course modules must be integrated.

27-411 Engineering Biomaterials

Fall: 9 units

This course will cover structure-processing-property relationships in biomaterials for use in medicine. This course will focus on a variety of materials including natural biopolymers, synthetic polymers, and soft materials with additional treatment of metals and ceramics. Topics include considerations in molecular design of biomaterials, understanding cellular aspects of tissue-biomaterials interactions, and the application of bulk and surface properties in the design of medical devices. This course will discuss practical applications of these materials in drug delivery, tissue engineering, biosensors, and other biomedical technologies. Cross-listed with 27-411

27-421 Processing Design

Fall: 6 units

In this course, the concepts of materials and process design are developed, integrating the relevant fundamental phenomena in a case study of a process design. The course includes basic science and engineering as well as economic and environmental considerations. The case study is on environmentally acceptable sustainable steelmaking. Other case studies in materials processing could be used.

27-432 Electronic and Thermal Properties of Metals, Semiconductors and Related Devices

Intermittent: 9 units

Fall even years This is Part I of a two-part course (Part II is 27-433) sequence concerned with the electrical, dielectric, magnetic and superconducting properties of materials. Students taking Part I will develop an in-depth understanding, based on the modern theories of solids, of the electrical, electronic and thermal properties of metals and semiconductors and the principles of operation of selected products and devices made from these materials. Overarching and interrelated topics will include elementary quantum and statistical mechanics, relationships between chemical bonds and energy bands in metals and semiconductors, the roles of phonons and electrons in the thermal conductivity of solids, diffusion and drift of electrons and holes, the important role of junctions in the establishment and control of electronic properties of selected metal- and semiconductor-based devices. Examples of commercial products will be introduced to demonstrate the application of the information presented in the text and reference books and class presentations. Additional topics will include microelectro-mechanical systems and nanoelectronics.

27-433 Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices

Intermittent: 9 units

Fall odd years: 9 units This is Part II of a two-part course sequence (Part I is 27-432) concerned with the electrical, dielectric, magnetic and superconducting properties of materials. Students taking Part II will develop an in-depth understanding, based on the modern theories of solids, of the dielectric, magnetic and superconducting properties of materials and the principles of operation of selected products and devices made from these materials. Topics will include relationships between chemical bonds and energy bands in dielectric and magnetic materials; polarization mechanisms in materials and their relationship to capacitance, piezoelectricity, ferroelectricity, and pyroelectricity; magnetization and its classification among materials; magnetic domains; soft and hard magnets; and the origin, theory and application of superconductivity. Examples of commercial products will be introduced to demonstrate the application of the information presented in the text and reference books and class presentations.

27-445 Structure, Properties and Performance Relationships in Magnetic Materials

Spring: 9 units

This course introduces the student to intrinsic properties of magnetic materials including magnetic dipole moments, magnetization, exchange coupling, magnetic anisotropy and magnetostriction. This is followed by discussion of extrinsic properties including magnetic hysteresis, frequency dependent magnetic response and magnetic losses. This will serve as the basis for discussing phase relations and structure/properties relationships in various transition metal magnetic materials classes including iron, cobalt and nickel elemental magnets, iron-silicon, iron-nickel, iron-cobalt and iron platinum. This will be followed by a discussion of rare earth permanent magnets, magnetic oxides, amorphous and nanocomposite magnets. Polymers used in Electromagnetic Interference (EMI) Absorbers applications will also be covered.

27-454 Supervised Reading

Spring

This course provides the opportunity for a detailed study of the literature on some subject under the guidance of a faculty member, usually but not necessarily in preparation for the Capstone Course, 27-401/402.

27-499 Professional Development III

Fall: 1 unit

This is a course that is designed to teach engineering business and professional skills to the MSE students. It is attended by sophomores, juniors and seniors and the courses Professional Topics I, II and III are given once per year on a three year cycle. Year 1: Work Place Skills, Leadership Skills and Teams Year 2: Project Management Year 3: Ethics, Business Planning, Lifetime Learning Although the course is not specifically designed as "metals, polymers, ceramics and composites", real world problems are used for examples and discussions. Assignments, when used, (for example, in project management or business planning) can be case studies or typical assignments a materials scientist may encounter during his/her employment.

27-501 Invention & Innovation for Materials Intensive Technologies Part 1

Fall: 4.5 units

Two 4.5 unit classes that can be taken in sequence or as stand-alone mini's. Courses will be cross-listed between EPP and MSE. This course is intended to instill a sense of how technologies are conceived and brought to market. The students will be exposed to a variety of formalized invention and innovation processes/concepts and will be asked to complete projects that will pull from the full range of their engineering training. It is intended for seniors who are eager to creatively apply their learned knowledge skills, and who are interested in invention, innovation, and entrepreneurship. The first half (part 1 (27-501), mini 1) will focus on the process of invention for devices and technologies that are enabled by materials functionality. This will start by providing historical context and addressing the questions "What is invention?" This will be followed by an assessment of various systematic methods by which the process of invention is practiced, with a specific focus on materials intensive devices and products. The second half of the course (part 2 (27-502) mini 2) will examine innovation theory in the context of materials intensive technologies. Specifically, the concepts of incumbency, disruption, value chain, supply chain, funding models and paths to market will be addressed. In this class, significant time will be dedicated to covering the impact of international market and technology development.

27-502 Invention and Innovation for Materials Intensive Technologies Part 2

Fall and Spring: 4.5 units

Two 4.5 unit classes that can be taken in sequence or as stand-alone mini's. Courses will be cross-listed between EPP and MSE. This course is intended to instill a sense of how technologies are conceived and brought to market. The students will be exposed to a variety of formalized invention and innovation processes/concepts and will be asked to complete projects that will pull from the full range of their engineering training. It is intended for seniors who are eager to creatively apply their learned knowledge skills, and who are interested in invention, innovation, and entrepreneurship. The first half (part 1 (27-501), mini 1) will focus on the process of invention for devices and technologies that are enabled by materials functionality. This will start by providing historical context and addressing the questions "What is invention?" This will be followed by an assessment of various systematic methods by which the process of invention is practiced, with a specific focus on materials intensive devices and products. The second half of the course (part 2 (27-502) mini 2) will examine innovation theory in the context of materials intensive technologies. Specifically, the concepts of incumbency, disruption, value chain, supply chain, funding models and paths to market will be addressed. In this class, significant time will be dedicated to covering the impact of international market and technology development. Prerequisites: 27-501 or 19-461

27-515 Special Topics

Fall: 9 units

This course introduces students to the theory and practice of computational materials science from the electronic to the microstructural scale. Both the underlying physical models and their implementation as computational algorithms will be discussed. Topics will include: -Density functional theory -Molecular dynamics -Monte Carlo methods -Phase field models -Cellular automata -Data science Coursework will utilize both software packages and purpose-built computer codes. Students should be comfortable writing, compiling, and running simple computer programs in C, C++, Fortran, MatLab, Python, or comparable environment.

27-519 Computational Thermodynamics

Spring: 9 units

Computational thermodynamics is a powerful tool of a Materials Engineer. We will examine how thermodynamic simulation software outputs an equilibrium calculation from a list of input conditions. This requires a description of Gibbs energy minimization calculations, Gibbs energy models, and the construction of these models from thermodynamic data. At the end of the class students should be able to use thermodynamic simulation software to solve engineering problems while recognizing its limitations. This class is for upper-level undergraduates and graduate students interested in these computational tools.

27-520 Tissue Engineering

Spring: 12 units

This course will train students in advanced cellular and tissue engineering methods that apply physical, mechanical and chemical manipulation of materials in order to direct cell and tissue function. Students will learn the techniques and equipment of bench research including cell culture, immunofluorescent imaging, soft lithography, variable stiffness substrates, application/measurement of forces and other methods. Students will integrate classroom lectures and lab skills by applying the scientific method to develop a unique project while working in a team environment, keeping a detailed lab notebook and meeting mandated milestones. Emphasis will be placed on developing the written and oral communication skills required of the professional scientist. The class will culminate with a poster presentation session based on class projects. Prereqs: Cell biology and Biomaterials, or permission of instructor.

27-533 Principles of Growth and Processing of Semiconductors

Fall: 6 units

Development of a fundamental understanding of material principles governing the growth and processing of semiconductors. Techniques to grow and characterize bulk crystals and epitaxial layers are considered. The processing of semiconductors into devices and the defects introduced thereby are discussed. The roles of growth- and processing-induced defects in determining long term reliability of devices are examined.

27-542 Processing and Properties of Thin Films

Fall: 9 units

This course is designed to provide an introduction to the science and technology of thin films, with special emphasis on methods to produce thin films and relationships between growth conditions and thin film properties. Topics include (1) various methods of thin film production, such as evaporation, sputtering and chemical vapor deposition, (2) nucleation and growth processes, (3) dimensional, chemical, and structural characterization of thin films and (4) properties and applications, such as conductivity and thin film solar cells.

27-551 Properties of Ceramics and Glasses

Spring: 9 units

This course describes some of diverse properties of ceramics and glasses, with a focus on those relevant to modern engineering applications. It includes discussions of the underlying science of selected ceramic properties, such as thermal properties, including heat capacity and thermal expansion; mechanical properties, including strength, toughness, and environmental effects; electrical properties, including electronic and ionic conductivity; dielectric properties, including piezoelectricity and ferroelectricity; and optical properties, as they pertain to glasses and lasers. Numerous examples of current applications, such as lasers, sensors, fiber optics, multilayer capacitors, solid oxide fuel cells, or thermoelectrics, are discussed throughout the course to illustrate the engineering relevance of fundamental phenomena. This class will be co-taught with 27-751. Undergraduates taking the course will have separate homework and exams from the graduate students, and will be graded separately from the graduate students.

27-555 Materials Project I

Fall

This course is designed to give experience in individualized research under the guidance of a faculty member. The topic is selected by mutual agreement, and will give the student a chance to study the literature, design experiments, interpret the results and present the conclusions orally and in writing.

27-556 Materials Project II

Spring

Second semester of Materials Project. This course is designed to give experience in individualized research under the guidance of a faculty member. The topic is selected by mutual agreement, and will give the student a chance to study the literature, design experiments, interpret the results and present the conclusions orally and in writing.

27-561 Special Topics: Kinetics of Metallurgical Reactions and Processes

Fall: 6 units

This class uses examples from the ironmaking and steelmaking to illustrate different rate-determining reaction steps. Reaction times in ironmaking and steelmaking process vary quite widely; the fundamental origins of the large differences in reaction time are analyzed, after a brief overview of the main reactions and process steps in ironmaking and steelmaking. Particular skills to be practiced and developed include derivation of the mathematical relationships which describe the rates of metallurgical processes which involve heat transfer, and mass transfer for solid-gas, liquid-gas and liquid-liquid reactions; quantifying the expected rates of such reactions; identification of rate-determining steps, based on calculated rates and observed reaction rates; predicting the effects of process parameters such as particle size, stirring, temperature and chemical compositions of phases on the overall rate; and critical evaluation of kinetic data and models in scientific papers on metallurgical reactions.

27-565 Nanostructured Materials

Intermittent: 9 units

Fall even years: This course is an introduction to nanostructured materials or nanomaterials. Nanomaterials are objects with sizes larger than the atomic or molecular length scales but smaller than microstructures with at least one dimension in the range of 1-100 nm. The physical and chemical properties of these materials are often distinctively different from bulk materials. This course introduces the basic thermodynamic concepts related to the phases, chemical activity and synthesis of nanomaterials including metallic, semiconductor, inorganic, liquid crystalline, polymeric and surfactant systems. The characterization of the structure of nanomaterials and their applications are also explored. At the end of the course, students should understand the relationship between the nanoscale structures, properties and performance of nanomaterials.

27-566 Special Topics in MSE: Using Materials Informatics to Assess Societal Impact of Materials

Fall and Spring: 9 units

Using Materials Informatics to Assess Societal Impact of Materials: For years Material Science and Engineering in general has been taught with emphasis on the technology and then looks at how this technology fits in to society through applications. This course will attempt to put forth an innovative approach, combining new data mining techniques, data analysis, and material fundamentals (materials informatics) to see if material failure patterns can be extracted from social media. The course will involve instruction on typical material issue that contribute to failures either geographically or temporarily. Students will also be introduced to informatics techniques related to data mining and large database analysis. The intent is to have a mix of lectures and practical project work. This course is primarily intended to be a course directed to CIT students in order to experience an understanding that engineering work is strongly connected to societal. Students that enroll should have completed their class in statistics.

27-570 Molecular and Micro-scale Polymeric Biomaterials in Medicine

9 units

This course will cover aspects of polymeric biomaterials in medicine from molecular principles to device scale design and fabrication. Topics include the chemistry, characterization, and processing of synthetic polymeric materials; cell-biomaterials interactions including interfacial phenomena, tissue responses, and biodegradation mechanisms; aspects of polymeric micro-systems design and fabrication for applications in medical devices. Recent advances in these topics will also be discussed. Pre-requisite: None.

27-582 Phase Transformations in Solids

Intermittent: 9 units

Spring even years: In this course the fundamental aspects of solid state phase transformations are presented. The nucleation (homogeneous and heterogeneous) and growth of diffusional and non-diffusional heterogeneous solid state transformations are discussed from the point of view of crystallography, thermodynamics and kinetics, as are the same aspects of homogeneous transformations. Details of such transformations as precipitation, cellular, atomic ordering, massive, spinodal decomposition, displacive, etc. are discussed with specific examples from the Materials Science literature.

27-588 Polymer Physics and Morphology

Intermittent: 9 units

This course introduces the fundamental concepts necessary to understand and determine the structure and properties of polymers in the solid state. The structure of polymers will be discussed with focus on the amorphous, crystalline and liquid-crystalline state. One aim is to provide a student intuition about the organization of polymer molecules in the solid state based on the polymer's chemical structure. Particular attention will be given to scattering techniques as a tool to determine polymer structures in solution and the solid state. The glass transition in amorphous polymers as well as the morphology and kinetics of crystal formation in semi-crystalline polymers will be discussed in detail. The second part of the course will focus on polymer multicomponent materials. Basic concepts of lattice models will be introduced and applied to predict the phase behavior of polymer blends.

27-591 Mechanical Behavior of Materials

Intermittent: 9 units

Spring odd years: Fundamentals of stress and strain. Linear elastic behavior. Tensile testing and yield criteria. Relationships between stress and strain for the case of plastic deformation. Theoretical strength. Tensile tests of single crystals and the idea of a slip system. Shear stress versus shear strain curves for single crystals and the effects of crystal orientation, temperature, atoms in solid solution and precipitates on the shapes of such curves. Taylor's connection between tensile curves of single crystals and those of polycrystalline samples. Dislocations and plastic deformation. Strengthening mechanisms including solid-solution strengthening, strengthening by precipitates, work hardening and grain size effects on strength. Approaches to quantifying the fracture resistance of materials, including the Griffith approach, the energy release rate approach and the stress intensity factor approach. Crack tip behavior including stresses and strains at crack tips and the plastic zone. Fracture mechanisms including ductile fracture, cleavage fracture and intergranular fracture. The fracture of highly brittle materials. Time permitting fatigue and creep of materials will be discussed.

27-592 Solidification Processing

Intermittent: 9 units

Spring odd years: The goal of this course is to enable the student to solve practical solidification processing problems through the application of solidification theory. The objectives of this course are to: (1) Develop solidification theory so that the student can understand predict solidification structure; (2) Develop a strong understanding of the role of heat transfer in castings; (3) Develop an appreciation for the strengths and weaknesses of a variety of casting processes. The first half of the course will be theoretical, covering nucleation, growth, instability, solidification microstructure: cells, dendrites, eutectic and peritectic structures, solute redistribution, inclusion formation and separation, defects and heat transfer problems. The second part of the course will be process oriented and will include conventional and near net shape casting, investment casting, rapid solidification and spray casting where the emphasis will be on process design to avoid defects.

27-699 Professional Skills in Materials Science and Engineering

Fall: 6 units

This course is intended for students in the masters program in Materials Science and Engineering. The course will expose students to important issues that materials scientists and engineers face when they enter the workforce. The course focuses on professional skills for materials scientists and engineers, covering communication skills, ethics and responsible conduct of research, and evaluating technical literature. The course will end with discussions on how materials science affects the global economy. Course activities will include in-class exercises and assignments based on case studies.

27-709 Engineering Biomaterials

Fall: 12 units

This course will cover structure-processing-property relationships in biomaterials for use in medicine. This course will focus on a variety of materials including natural biopolymers, synthetic polymers, and soft materials with additional treatment of metals and ceramics. Topics include considerations in molecular design of biomaterials, understanding cellular aspects of tissue-biomaterials interactions, and the application of bulk and surface properties in the design of medical devices. This course will discuss practical applications of these materials in drug delivery, tissue engineering, biosensors, and other biomedical technologies. This course is a project-based option for graduate students that is taught concurrently with 42-411.

27-715 Applied Magnetism and Magnetic Materials

Spring: 12 units

In this course we address the physics of magnetism of solids with emphasis on magnetic material properties and phenomena which are useful in various applications. The content of this course includes the origins of magnetism at the atomic level and the origins of magnetic ordering (ferro-, ferri-, and antiferromagnetism), magnetic anisotropy, magnetic domains, domain wall, spin dynamics, and transport at the crystalline level. The principles of magnetic crystal symmetry are utilized to explore the various domains in ferromagnetic crystals, and tensors are used in the description of such magnetic properties as magnetocrystalline anisotropy, susceptibility and magnetostriction. To a limited extent, the applications of magnetism are discussed in order to motivate the understanding of the physical properties and phenomena.

27-718 Soft Materials

Fall: 12 units

The emphasis in this course will be on the emerging unifying physical principles that explain the macroscopic properties of a wide variety of soft materials, e.g., colloids, liquid crystals, surfactants, polymers, and biological structures. At the end of the course, students should understand the concepts, experimental techniques, and open questions in the field. The course is interdisciplinary, and it is expected that enrollment will cover a wide spectrum of students. Therefore, the essential concepts will be taught as necessary. Prerequisites: Graduate standing or permission of instructor.

27-719 Computational Thermodynamics

Spring: 12 units

Computational thermodynamics is a powerful tool of a Materials Engineer. We will examine how thermodynamic simulation software outputs an equilibrium calculation from a list of input conditions. This requires a description of Gibbs energy minimization calculations, Gibbs energy models, and the construction of these models from thermodynamic data. At the end of the class students should be able to use thermodynamic simulation software to solve engineering problems while recognizing its limitations. This class is for graduate students interested in these computational tools.

27-721 Processing Design

Fall: 6 units

In this course, the concepts of materials and process design are developed, integrating the relevant fundamental phenomena in a case study of a process design. The course includes basic science and engineering as well as economic and environmental considerations. The case study is on environmentally acceptable sustainable steelmaking. Other case studies in materials processing could be used.

27-724 Materials for Energy Storage

Intermittent: 6 units

This course will examine functional materials used to store and release electrical energy. An overview of the thermodynamics of power, energy and energy storage will be used to motivate subsequent investigations into the dominant methods in use today: electrochemical, electrical, and electromechanical (chemical/combustion and nuclear processes will not be covered). For each sub-topic, the physical and chemical mechanisms exploited will be discussed, followed by a detailed exposition of specific materials functionality and device applications. Particular focus will be given to several relevant emerging technologies: Li-ion batteries, hydrogen-based fuel cells (polymer proton exchange membrane and solid-oxide based systems), and large capacitors (both electrolytic and dielectric).

27-725 Materials for Nuclear Energy Systems

Spring: 6 units

Students in this course will learn about Materials that are used in nuclear energy systems. The course will cover the full range of materials that are relevant to nuclear energy with a focus on materials subject to irradiation (glasses, steels, nickel alloys, and zirconium alloys). Applications of materials will include waste storage, reactor vessels, turbines, pumps, piping, and fuel elements. For the materials used in each application, the selection and performance criteria will be considered as well as the underlying structure, thermodynamic, and kinetic processes that influence materials properties. The effects of irradiation on materials properties and performance will be examined. Key properties include strength, fracture toughness and corrosion resistance. Many of these properties continue to change over the long service periods expected of components. In addition to lectures and homeworks, each student will complete a detailed case study in which they examine a particular material and application.

27-727 Mechanical Behavior in Extreme Environments

Spring: 6 units

The purpose of this course is to discuss the mechanical behavior of materials used in extreme environments in the production and distribution of energy. The focus will be on the production and refining of oil, conventional power plants and nuclear power plants. The course will begin with a discussion of the materials used in these applications and this discussion will focus on compositions, heat treatment, microstructure and nominal mechanical properties after heat treatment. The materials will include low alloy steels, stainless steels, nickel base alloys and zirconium alloys used as fuel cladding in nuclear reactors. The mechanical behavior discussed will be the behavior of materials at high temperatures, various types of stress corrosion cracking and the toughness of steels used at low temperatures. In addition, various forms of embrittlement associated with long service times at elevated temperatures will be discussed. These will include hydrogen attack, temper embrittlement due to segregation of impurities and alloying elements, the formation of phases which result in embrittlement and embrittlement due to irradiation in nuclear reactors. Many of these materials are expected to be in service for many years so, where time permits, methodologies used to predict mechanical properties after long times in service will be discussed.

27-729 Solid State Devices for Energy Conversion

Intermittent: 6 units

Intensive research efforts have yielded promising new materials approaches to 'alternative' energy conversion technologies, such as solar cells or photovoltaics; thermoelectric materials, which convert waste heat to electricity; metal/semiconductor superlattices for thermionic energy conversion; and fuel cells. At the same time, notable advances have been made in devices that substantially enhance our energy efficiency: e.g., chemical sensors and light-emitting diodes for solid-state lighting. In all of these devices, interfaces between dissimilar materials often govern and/or limit the behavior. In addition to the basic structures and operating principles, this course will cover practical materials interface issues, such as electrical transport, thermal stability, contact resistance, and bandgap engineering, that significantly affect the performance of a variety of energy conversion and energy-saving devices.

27-731 SPECIAL TOPICS: Hard and Superhard Materials

Intermittent: 6 units

This course will focus on the fundamental principles hard and superhard materials and coatings. We will first discuss the origin of hardness across materials, and then describe important examples of materials prized for either their intrinsic or extrinsic hardness. We will focus on the preparation, microstructure, and properties of materials such as diamond, cubic boron nitride and compound carbides. Additionally, we will emphasize the design of novel nano-structured and nano-composite materials and coatings, which are at the frontier of materials science. Finally, the course will present examples of the architecture and processing methods used to generate hard materials and coatings in manufacturing, automotive and aerospace industries.

27-752 Foundations of Semiconductor Nanostructures

Spring: 12 units

This course is designed to provide students with a foundation of the physics required to understand nanometer-scale structures and to expose them to different aspects of on-going research in nanoscience and nanotechnology. Illustrative examples will be drawn from the area of semiconductor nanostructures, including their applications in novel and next-generation electronic, photonic, and sensing devices. The course begins with a review of basic concepts in quantum physics (wave-particle duality, Schrödinger's equation, particle-in-a-box, approximation methods in quantum mechanics, etc.) and then continues with a discussion of bulk three-dimensional solids (band structure, density of states, the single-electron effective-mass approximation). Size effects due to nanometer-scale spatial localization are then discussed within a quantum-confinement model in one-, two-, and three- dimensions for electrons. An analogous discussion for photons is also presented. The basic electronic, optical, and mechanical properties of the low-dimensional nanostructures are then discussed. A select number of applications in electronics, photonics, biology, chemistry, and bio-engineering will be discussed to illustrate the range of utility of nanostructures. Upon completion of the course, students will have an appreciation and an understanding of some of the fundamental concepts in nanoscience and nanotechnology. The course is suitable for first-year graduate students in engineering and science (but advanced undergraduates with appropriate backgrounds may also take it with permission from the instructor). Pre-requisites include 09-511, 09-701, 09-702, 18-311, 27-770, 33-225, 33-234 or familiarity with the material or basic concepts covered in these courses.

27-756 Masters Project

All Semesters

Individual research project, including laboratory, theoretical, library or design work followed by a written or oral report on the work accomplished.

27-761 Special Topics: Kinetics of Metallurgical Reactions and Processes

Fall: 6 units

This class uses examples from the ironmaking and steelmaking to illustrate different rate-determining reaction steps. Reaction times in ironmaking and steelmaking process vary quite widely; the fundamental origins of the large differences in reaction time are analyzed, after a brief overview of the main reactions and process steps in ironmaking and steelmaking. Particular skills to be practiced and developed include derivation of the mathematical relationships which describe the rates of metallurgical processes which involve heat transfer, and mass transfer for solid-gas, liquid-gas and liquid-liquid reactions; quantifying the expected rates of such reactions; identification of rate-determining steps, based on calculated rates and observed reaction rates; predicting the effects of process parameters such as particle size, stirring, temperature and chemical compositions of phases on the overall rate; and critical evaluation of kinetic data and models in scientific papers on metallurgical reactions.

27-766 Diffusion in Materials

Fall: 6 units

This course is designed to allow the student to become familiar with the fundamental principles diffusion in solid materials. The course will include the treatment of diffusion from an atomic scale to micro-structural scales in metals, ceramics, glasses and polymers. In addition, the student will develop skills and methodologies necessary to apply mathematical methods to solve differential equations of relevance to diffusion problems including separation of variables, Laplace transforms and Green's functions. An introduction will be given to the application of numerical solutions. Where appropriate, examples will be taken from problems related to the design of components and the processing and performance of materials.

27-782 Phase Transformations in Solids I

Spring: 12 units

Special topics in applied thermodynamics, with particular emphasis on free energy-composition diagrams and their applications, are developed in some detail. The kinetic equations of both classical and non-classical nucleation theory are then derived. Special emphasis is placed upon the influence of the critical nucleus shape, and the nucleation site, upon nucleation kinetics. The limited experimental evidence available for testing nucleation theory is critically examined. The principal relationships for diffusional growth are next deduced. The structure of interphase boundaries is considered both theoretically and experimentally and its influence upon growth kinetics is demonstrated through comparisons of calculated and measured growth kinetics in model alloy systems. 4 hrs. lec.

27-788 Defects in Materials

Fall: 6 units

This course addresses the fundamental properties of defects in crystalline solids, as well as their effects on properties and behavior of materials. Primary attention is devoted to point and line defects. Somewhat less comprehensive coverage is given to extended defects, including grain boundaries, interphase boundaries and surfaces. 4 hrs. lec.

27-791 Mechanical Behavior of Materials

Spring: 12 units

The intent of the course is to introduce various measures indicative of the performance of materials in applications. Properties often used in selecting materials will be introduced, and connections between these properties and microstructure will be developed. Mechanical properties are emphasized in this course. 4 hrs. lec.

27-792 Solidification Processing

Spring: 12 units

The goal of this course is to enable the student to solve practical solidification processing problems through the application of solidification theory. The objectives of this course are to: (1) Develop solidification theory so that the student can understand predict solidification structure; (2) Develop a strong understanding of the role of heat transfer in castings; (3) Develop an appreciation for the strengths and weaknesses of a variety of casting processes. The first half of the course will be theoretical, covering nucleation, growth, instability, solidification microstructure: cells, dendrites, eutectic and peritectic structures, solute redistribution, inclusion formation and separation, defects and heat transfer problems. The second part of the course will be process oriented and will include conventional and near net shape casting, investment casting, rapid solidification and spray casting where the emphasis will be on process design to avoid defects.

27-796 Structure of Materials

6 units

The skills and ideas necessary to understand the atomic structure of crystalline materials are presented. The objective is for the student to be able to describe crystal structures based on their symmetry (Bravais lattices, point groups and space groups) as well as packing configurations and to understand how diffraction is used to experimentally probe crystal structures.

27-797 Bonding of Materials

6 units

Models for cohesive forces in crystals are reviewed; both quantitative and phenomenological descriptions of secondary, ionic, metallic, and covalent bonds are discussed. A band structure language is developed starting from free electron and LCAO models of metals and covalently bonded crystals, respectively. 4 hrs lecture
Prerequisites: 33-225 or 33-234

27-798 Thermodynamics I

Fall: 6 units

Course Description: The laws, concepts, and definitions of classical thermodynamics as well selected relationships that matter exhibits will be covered and applied to gas, liquid and crystalline systems. Concepts and classifications of thermodynamic systems, variables and relationships will be presented and discussed. General criteria and conditions for equilibrium will be developed and applied. The basic concepts of statistical thermodynamics will be introduced and applied to the interpretation of entropy. Alternate statistical formulations will be introduced and compared.

27-799 Thermodynamics II

Fall: 6 units

Course Description: The course will apply thermodynamic fundamentals covered in Thermodynamics I (27-780) to unary and to multi-component materials systems. The course will also cover phase diagrams, predominance diagrams, chemical reactions and thermodynamics of surfaces.

Mathematical Sciences Courses

21-101 Freshman Mathematics Seminar

Fall: 3 units

This course is offered in the Fall semester for first semester Freshmen interested in majoring in mathematics. Topics vary from year to year. Recent topics have included Fermat's last theorem, finite difference equations, convexity, and fractals. 3 hrs. lec.

21-105 Pre-Calculus

Summer: 9 units

Review of basic concepts, logarithms, functions and graphs, inequalities, polynomial functions, complex numbers, and trigonometric functions and identities. Special summer program only. 3 hrs lec., 1 hr.ec.

21-110 Problem Solving in Recreational Mathematics

Spring: 9 units

The emphasis is on learning to solve problems in elementary mathematics. Topics may vary among offerings of the course, but typically include puzzles, algebraic problems, number theory, and graph theory. 3 hrs. lec.

21-111 Calculus I

Fall and Spring: 10 units

Review of basic algebra, functions, limits, derivatives of algebraic, exponential and logarithmic functions, curve sketching, applications with emphasis on economic models. Successful completion of 21-111 and 21-112 entitles a student to enroll in any mathematics course for which 21-120 is a prerequisite. 3 hrs. lec., 2 hrs. rec.

21-112 Calculus II

Fall and Spring: 10 units

Indefinite integral, definite integral and applications, techniques of integration, trigonometric functions, functions of several variables, partial derivatives, maximum-minimum problems, Lagrange multipliers, geometric series, Newton's method, applications. Successful completion of 21-111 and 21-112 entitles a student to enroll in any mathematics course for which 21-120 is a prerequisite. 3 hrs. lec., 2 hrs. rec.
Prerequisite: 21-111

21-115 Basic Differential Calculus

Summer: 5 units

Functions, limits, derivatives, curve sketching, Mean Value Theorem, trigonometric functions, related rates, linear and quadratic approximations, maximum-minimum problems. Special summer program only.

21-120 Differential and Integral Calculus

All Semesters: 10 units

Functions, limits, derivatives, logarithmic, exponential, and trigonometric functions, inverse functions; L'Hospital's Rule, curve sketching, Mean Value Theorem, related rates, linear and quadratic approximations, maximum-minimum problems, inverse functions, definite and indefinite integrals, and hyperbolic functions; applications of integration, integration by substitution and by parts. 3 hrs lec., 2 hrs. rec.

21-122 Integration and Approximation

Fall and Spring: 10 units

Integration by trigonometric substitution and partial fractions; arclength; improper integrals; Simpson's and Trapezoidal Rules for numerical integration; separable differential equations, Newton's method, Euler's method, Taylor's Theorem including a discussion of the remainder, sequences, series, power series. Parametric curves, polar coordinates, vectors, dot product. 3 hrs lec., 2 hrs. rec.
Prerequisites: 21-112 or 21-120

21-124 Calculus II for Biologists and Chemists

Spring: 10 units

This is intended as a second calculus course for biology and chemistry majors. It uses a variety of computational techniques based around the use of MATLAB or a similar system. Topics to be covered include: Integration: techniques and numerical integration. Ordinary differential equations: techniques for solving ODEs and numerical methods. Modeling with ODEs (e.g., infection, population models). Linear algebra: matrices, complex numbers, eigenvalues, eigenvectors. Systems of ordinary differential equations (if time allows: stability of differential systems). Probability: discrete and continuum probability, conditional probability and independence, limit theorems, important distributions, probabilistic models. 3 hrs. lec., 2 hrs. rec. Prerequisite: 21-112 or 21-120.
Prerequisites: 21-112 or 21-120

21-126 Introduction to Mathematical Software

Fall and Spring: 3 units

This course provides an introduction to the use of several software packages, which are useful to mathematics students. Among the packages are Maple and Mathematica for symbolic computing, TeX and LaTeX for mathematical documents, and Matlab for numerical computing. The course will also introduce the mathematical facilities built into spreadsheets such as Excel. The aim of the course is to provide the student with some basic skills in the use of this software without attempting complete coverage. A deeper knowledge of the software will be easy to obtain after completing this course. There are no prerequisites for the course, other than basic computer literacy and a knowledge of elementary mathematics. It is suggested that the course should be taken during the first two years of undergraduate studies.

21-127 Concepts of Mathematics

Fall and Spring: 10 units

This course introduces the basic concepts, ideas and tools involved in doing mathematics. As such, its main focus is on presenting informal logic, and the methods of mathematical proof. These subjects are closely related to the application of mathematics in many areas, particularly computer science. Topics discussed include a basic introduction to elementary number theory, induction, the algebra of sets, relations, equivalence relations, congruences, partitions, and functions, including injections, surjections, and bijections. A basic introduction to the real numbers, rational and irrational numbers. Supremum and infimum of a set. 3 hrs. lec., 2 hrs. rec.

21-128 Mathematical Concepts and Proofs

Intermittent: 12 units

This course is intended for MCS first-semester students who are interested in pursuing a major in mathematical sciences. The course introduces the basic concepts, ideas and tools involved in doing mathematics. As such, its main focus is on presenting informal logic, and the methods of mathematical proof. These subjects are closely related to the application of mathematics in many areas, particularly computer science. Topics discussed include a basic introduction to elementary number theory, induction, the algebra of sets, relations, equivalence relations, congruences, partitions, and functions, including injections, surjections, and bijections. A basic introduction to the real numbers, rational and irrational numbers. Supremum and infimum of a set. This course is a superset of 21-127, with additional out of class time devoted to proofs and additional topics in math. 3 hrs. lec., 2 hrs. rec.

21-201 Undergraduate Colloquium

Fall and Spring: 1 unit

All mathematics majors meet for one hour each week to hear discussions on current research by faculty or students, presentations on mathematics from mathematicians outside academia, and expository talks on selected mathematical topics not part of the usual curricula. Also will include topics of special interest to undergraduates such as preparation for graduate school.

21-228 Discrete Mathematics

Spring: 9 units

The techniques of discrete mathematics arise in every application of mathematics, which is not purely continuous, for example in computer science, economics, and general problems of optimization. This course introduces two of the fundamental areas of discrete mathematics: enumeration and graph theory. The introduction to enumeration includes permutations, combinations, and topics such as discrete probability, combinatorial distributions, recurrence relations, generating functions, Ramsey's Theorem, and the principle of inclusion and exclusion. The introduction to graph theory includes topics such as paths, walks, connectivity, Eulerian and Hamilton cycles, planar graphs, Euler's Theorem, graph coloring, matchings, networks, and trees. 3 hrs. lec, 1 hr. rec.
Prerequisite: 21-127

21-235 Mathematical Studies Analysis I

Fall: 10 units

An honors version of 21-355 for students of greater aptitude and motivation. Topics to be covered include: The Real Number System: sups and infs, completeness, integers and rational numbers. Metric spaces, normed spaces, inner product spaces and their specialization to the Euclidean space. Topological properties of metric spaces (open sets, closed sets, density, compactness, Heine-Borel Theorem). Sequences and convergence; completeness. Baire Category Theorem. Real sequences: limsup and liminf, subsequences, monotonic sequences, Bolzano-Weierstrass Theorem. Real series (criteria for convergence). Continuity, limits of functions, attainment of extrema, Intermediate Value Theorem, uniform continuity. Differentiation of functions of one variable: Chain Rule, local extrema, Mean-Value Theorems, L'Hôpital's Rule, Taylor's Theorem. Riemann Integration: Partitions, upper and lower integrals, sufficient conditions for integrability, Fundamental Theorem of Calculus. 3 hrs. lec.
Prerequisites: 21-127 and 21-269

21-236 Mathematical Studies Analysis II

Spring: 10 units

An honors version of 21-356 for students of greater aptitude and motivation. Topics to be covered include: Vector differential calculus: differentiability, partial derivatives, directional derivatives, gradients, Jacobians, the chain rule, implicit function theorem, inverse function theorem. Local extrema, constrained problems (Lagrange multipliers). Integration of differential forms: Manifolds, Differential forms (properties, differentiation, change of variables), partition of unity, integration, volume form, area form, Stokes' theorem. Sequences of Functions: Pointwise convergence, uniform convergence, Arzela-Ascoli, Weierstrass approximation theorem. Series of functions: Power series, Fourier series, orthonormal bases. 3 hrs. lec.
Prerequisites: 21-235 and 21-242
Corequisite: 21-238

21-237 Mathematical Studies Algebra I

Fall: 10 units

An honors version of 21-373 Algebraic structures for students of greater aptitude and motivation. Abstract algebra is the study of algebraic systems by the axiomatic method, and it is one of the core areas of modern mathematics. This course is a rigorous and fast-paced introduction to the basic objects in abstract algebra. Topics to be covered include: Homomorphisms. Subgroups, cosets, Lagrange's theorem. Conjugation. Normal subgroups, quotient groups, first isomorphism theorem. Automorphisms, the automorphism group, characteristic subgroups. Group actions, Cauchy's Theorem, Sylow's theorem. Normalisers and centralisers, class equation, finite p -groups. Dihedral and alternating groups. The second and third isomorphism theorems. Simple groups, statement of Jordan-Hölder theorem, semidirect product of groups. Subrings, ideals, quotient rings, first isomorphism theorem. Polynomial rings. Zorn's Lemma. Prime and maximal ideals, prime and irreducible elements. PIDs and UFDs. Noetherian domains. Hilbert Basis Theorem. Gauss' lemma. Eisenstein criterion. Field of fractions of an integral domain. k a field implies $k[x]$ a PID, R a UFD implies $R[x]$ a UFD. Finite fields and applications. 3 hrs. lec.
Prerequisites: 21-127 and 21-269

21-238 Mathematical Studies Algebra II

Spring: 10 units

An honors version of 21-341 Linear Algebra for students of greater aptitude and motivation. Linear algebra is a crucial tool in pure and applied mathematics. This course aims to introduce the main ideas at a high level of rigour and generality. The course starts with the study of (potentially) infinite-dimensional vector spaces over an arbitrary field, continues with the theory of modules (where the role of the field is now played by an arbitrary ring), and concludes with the development of real and complex inner product spaces. Topics to be covered include: Review of fields. Review of Zorn's Lemma. Vector spaces (possibly in finite dimensional) over an arbitrary field. Independent sets, bases, existence of a basis, exchange lemma, dimension. Linear transformations, dual space. Multilinear maps, tensor product, exterior power, determinant of a transformation. Eigenvalues, eigenvectors, characteristic and minimal polynomial of a transformation, Cayley-Hamilton theorem. Review of commutative rings. R -modules. Sums and quotients of modules. Free modules. Structure theorem for fg modules over a PID and applications (Jordan and rational canonical form, structure theory of fg abelian groups). Review of real and complex numbers. Real and complex inner product spaces. Orthonormal sets, orthonormal bases, Gram-Schmidt. Examples: F^n and $l^2(F)$ for $F = R; C$. Operators: Symmetric/Hermitian and Orthogonal/Unitary operators. Spectral theorem. Quadratic forms. Singular value decomposition. Possible additional topics (time permitting): applications to combinatorics, category theory, representations of finite groups, normed spaces. 3 hrs. lec.
Prerequisites: 21-242 and 21-237

21-240 Matrix Algebra with Applications

Fall and Spring: 10 units

Vectors and matrices, the solution of linear systems of equations, vector spaces and subspaces, orthogonality, determinants, real and complex eigenvalues and eigenvectors, linear transformations. The course is intended for students in Economics, Statistics, Information Systems, and it will focus on topics relevant to these fields. 3 hrs. lec., 1 hr. rec.

21-241 Matrices and Linear Transformations

Fall and Spring: 10 units

A first course in linear algebra intended for scientists, engineers, mathematicians and computer scientists. Students will be required to write some straightforward proofs. Topics to be covered: complex numbers, real and complex vectors and matrices, row space and column space of a matrix, rank and nullity, solving linear systems by row reduction of a matrix, inverse matrices and determinants, change of basis, linear transformations, inner product of vectors, orthonormal bases and the Gram-Schmidt process, eigenvectors and eigenvalues, diagonalization of a matrix, symmetric and orthogonal matrices. 21-127 is strongly recommended. 3 hrs. lec., 1 hr. rec

21-242 Matrix Theory

Fall and Spring: 10 units

An honors version of 21-241 (Matrix Algebra and Linear Transformations) for students of greater aptitude and motivation. More emphasis will be placed on writing proofs. Topics to be covered: complex numbers, real and complex vectors and matrices, row space and column space of a matrix, rank and nullity, solving linear systems by row reduction of a matrix, inverse matrices and determinants, change of basis, linear transformations, inner product of vectors, orthonormal bases and the Gram-Schmidt process, eigenvectors and eigenvalues, diagonalization of a matrix, symmetric and orthogonal matrices, hermitian and unitary matrices, quadratic forms. 3 hrs. lec., 1 hr. rec.

21-256 Multivariate Analysis

Fall and Spring: 9 units

This course is designed for students in Economics or Business Administration. Matrix algebra: vectors, matrices, systems of equations, dot product, cross product, lines and planes. Optimization: partial derivatives, the chain rule, gradient, unconstrained optimization, constrained optimization (Lagrange multipliers and the Kuhn-Tucker Theorem). Improper integrals. Multiple integration: iterated integrals, probability applications, triple integrals, change of variables. 3 hrs lec., 1 hr rec.
Prerequisites: 21-120 or 21-112

21-257 Models and Methods for Optimization

Fall and Spring: 9 units

Introduces basic methods of operations research and is intended primarily for Business Administration and Economics majors. Review of linear systems; linear programming, including the simplex algorithm, duality, and sensitivity analysis; the transportation problem; the critical path method; the knapsack problem, traveling salesman problem, and an introduction to set covering models. 3 hrs. lec., 1 hr. rec.
Prerequisites: 21-240 or 21-256 or 21-242 or 21-241 or 18-202 or 06-262

21-259 Calculus in Three Dimensions

Fall and Spring: 9 units

Vectors, lines, planes, quadratic surfaces, polar, cylindrical and spherical coordinates, partial derivatives, directional derivatives, gradient, divergence, curl, chain rule, maximum-minimum problems, multiple integrals, parametric surfaces and curves, line integrals, surface integrals, Green-Gauss theorems. 3 hrs. lec., 1 hr. rec.
Prerequisite: 21-122

21-260 Differential Equations

Fall and Spring: 9 units

Ordinary differential equations: first and second order equations, applications, Laplace transforms; partial differential equations: partial derivatives, separation of variables, Fourier series; systems of ordinary differential equations; applications. 21-259 or 21-268 or 21-269 are recommended. 3 hrs. lec., 1 hr. rec.
Prerequisite: 21-122

21-261 Introduction to Ordinary Differential Equations

Spring: 10 units

A first course in ordinary differential equations intended primarily for math majors and for those students interested in a more conceptual treatment of the subject. One of the goals of this course is to prepare students for upper level courses on differential equations, mathematical analysis and applied mathematics. Students will be required to write rigorous arguments. Topics to be covered: Ordinary differential equations: first and second order equations, applications, Laplace transform, systems of linear ordinary differential equations; systems of nonlinear ordinary differential equations, equilibria and stability, applications. Note: Courses 21-259, or 21-268, or 21-269 are recommended. 3 hrs. lec., 1 hr. rec.
Prerequisite: 21-122
Corequisites: 21-241 and 21-127

21-268 Multidimensional Calculus

Fall and Spring: 10 units

A serious introduction to multidimensional calculus that makes use of matrices and linear transformation. Results will be stated carefully and rigorously. Students will be expected to write some proofs; however, some of the deeper results will be presented without proofs. Topics to be covered include: functions of several variables, regions and domains, limits and continuity, partial derivatives, linearization and Jacobian matrices, chain rules, inverse and implicit functions, geometric applications, higher derivatives, Taylor's theorem, optimization, vector fields, multiple integrals and change of variables, Leibnitz's rule, line integrals, Green's theorem, path independence and connectedness, conservative vector fields, surfaces and orientability, surface integrals, divergence theorem and Stokes's theorem. 3 hrs. lec.
Prerequisites: 21-122 and (21-241 or 21-242)

21-269 Vector Analysis

Spring: 10 units

An honors version of 21-268 for students of greater aptitude and motivation. More emphasis will be placed on writing proofs. Topics to be covered include: basic geometry and topology of Euclidean space, curves in space, arclength, curvature and torsion, functions on Euclidean spaces, limits and continuity, partial derivatives, gradients and linearization, chain rules, inverse and implicit function theorems, geometric applications, higher derivatives, Taylor's theorem, optimization, vector fields, multiple integrals and change of variables, Leibnitz's rule, conservative and solenoidal vector fields, divergence and curl, surfaces and orientability, surface integrals, Gauss-Green theorems and Stokes's theorem. A grade of B or better in 21-242 is required. 3 hrs. lec.
Prerequisite: 21-242

21-270 Introduction to Mathematical Finance

Spring: 9 units

This is a first course for those considering majoring or minoring in Computational Finance. The theme of this course is pricing derivative securities by replication. The simplest case of this idea, static hedging, is used to discuss net present value of a non-random cash flow, internal rate of return, and put-call option parity. Pricing by replication is then considered in a one-period random model. Risk-neutral probability measures, the Fundamental Theorems of Asset Pricing, and an introduction to expected utility maximization and mean-variance analysis are presented in this model. Finally, replication is studied in a multi-period binomial model. Within this model, the replicating strategies for European and American options are determined. 3 hrs. lec.
Prerequisites: 21-112 or 21-120

21-272 Introduction to Partial Differential Equations

Fall: 9 units

A Partial Differential Equation (PDE for short) is a differential equation involving derivatives with respect to more than one variable. These arise in numerous applications from various disciplines. A prototypical example is the heat equation, governing the evolution of temperature in a conductor. This course will serve as a first introduction to PDE's, and will focus on the most important model equations. It will cover both analytical methods (e.g. separation of variables, Green's functions), numerical methods (e.g. finite elements) and the use of a computer to approximate and visualize solutions. Time permitting, it will touch upon the mathematical ideas behind phenomena observed in nature (e.g. speed of wave propagation, and/or shocks in traffic flow).
Prerequisites: (21-268 or 21-269 or 21-259) and (21-261 or 33-231 or 21-260)

21-292 Operations Research I

Spring: 9 units

Operations research offers a scientific approach to decision making, most commonly involving the allocation of scarce resources. This course develops some of the fundamental methods used. Linear programming: the simplex method and its linear algebra foundations, duality, post-optimality and sensitivity analysis; the transportation problem; the critical path method; non-linear programming methods. 3 hrs. lec., 1 hr. rec.
Prerequisites: 21-122 and (21-241 or 21-242)

21-295 Putnam Seminar

Fall: 3 units

A problem solving seminar designed to prepare students to participate in the annual William Lowell Putnam Mathematical Competition. Students solve and present their solutions to problems posed.

21-296 Millennium Problems Seminar

Intermittent: 3 units

This seminar course will discuss some of the most important unsolved problems of mathematics (as deemed in 2000 by an international committee of mathematicians): The Riemann Hypothesis; Yang-Mills Theory and the Mass Gap Hypothesis; the P. vs. NP Problem; smoothness of solutions of the Navier-Stokes Equations; the Hodge Conjecture; the Birch and Swinnerton-Dyer Conjecture. If the time allows, the Poincare conjecture will also be discussed. 1 hr. lec.

21-300 Basic Logic

Fall: 9 units

Propositional and predicate logic: Syntax, proof theory and semantics up to completeness theorem, Lowenheim Skolem theorems, and applications of the compactness theorem. 3 hrs. lec.
Prerequisites: 15-251 or 21-373 or 21-228

21-301 Combinatorics

Fall: 9 units

A major part of the course concentrates on algebraic methods, which are relevant in the study of error correcting codes, and other areas. Topics covered in depth include permutations and combinations, generating functions, recurrence relations, the principle of inclusion and exclusion, and the Fibonacci sequence and the harmonic series. Additional topics may include existence proofs, partitions, finite calculus, generating combinatorial objects, Polya theory, codes, probabilistic methods. 3 hrs. lec
Prerequisites: 21-122 and (15-251 or 21-228)

21-302 Lambda Calculus

Spring: 9 units

An introductory course in classical lambda calculus, with an emphasis on syntax. The course will describe many research problems which are suitable topics for senior theses or master's theses. Topics will include: Basic properties of reduction and conversion; Reduction and conversion strategies; Calculability and representation of data types; Elementary theory of Ershov numberings; Bohm's theorem, easy terms, and other exotic combinations; Solvability of functional equations (unification); Combinatorics and bases; Simple and algebraic types; Labelled reduction and intersection types; Extensionality and the omega rule.
Prerequisite: 21-300

21-320 Symbolic Programming Methods

Spring: 9 units

The objective of this course is to learn to program in Maple, a powerful symbolic mathematics package available on many platforms at Carnegie Mellon. After learning what Maple can do with the commands provided with the package, students will learn to develop their own Maple functions to accomplish extended mathematical computations. Grades in the course will be based mostly on project work. Projects may come from any relevant field and may be graphical, numerical, or symbolic or all three. The course will involve online demonstrations in most classes. 3 hrs. lec.

Prerequisites: 21-127 and 21-122

21-325 Probability

Fall: 9 units

This course focuses on the understanding of basic concepts in probability theory and illustrates how these concepts can be applied to develop and analyze a variety of models arising in computational biology, finance, engineering and computer science. The firm grounding in the fundamentals is aimed at providing students the flexibility to build and analyze models from diverse applications as well as preparing the interested student for advanced work in these areas. The course will cover core concepts such as probability spaces, random variables, random vectors, multivariate densities, distributions, expectations, sampling and simulation; independence, conditioning, conditional distributions and expectations; limit theorems such as the strong law of large numbers and the central limit theorem; as well as additional topics such as large deviations, random walks and Markov chains, as time permits. 3 hrs. lec.

Prerequisites: 21-259 or 21-269 or 21-268

21-329 Set Theory

Spring: 9 units

Set theory was invented about 110 years ago by George Cantor as an instrument to understand infinite objects and to compare different sizes of infinite sets. Since then set theory has come to play an important role in several branches of modern mathematics, and serves as a foundation of mathematics. Contents: Basic properties of natural numbers, countable and uncountable sets, construction of the real numbers, some basic facts about the topology of the real line, cardinal numbers and cardinal arithmetic, the continuum hypothesis, well ordered sets, ordinal numbers and transfinite induction, the axiom of choice, Zorn's lemma. Optional topics if time permits: Infinitary combinatorics, filters and large cardinals, Borel and analytic sets of reals. 3 hrs. lec.

Prerequisite: 21-127

21-341 Linear Algebra

Fall and Spring: 9 units

21-341 Linear Algebra. A mathematically rigorous treatment of Linear Algebra over an arbitrary field. Topics studied will include abstract vector spaces, linear transformations, determinants, eigenvalues, eigenvectors, inner products, invariant subspaces, canonical forms, the spectral theorem and the singular value decomposition. 21-373 recommended. 3 hrs. lec.

Prerequisites: 21-241 or 21-242

21-350 History of Mathematics

Intermittent: 9 units

Mathematics has a long and interesting history, and there is much insight into both mathematics and history to be gained from its study. The emphasis here will be on learning the mathematics with the added value of appreciating it in historical context. Selected topics may range from early number systems, the development of geometry, the emergence of the ideas of analysis, through to the origins of modern set theory. 3 hrs. lec.

21-355 Principles of Real Analysis I

Fall and Spring: 9 units

This course provides a rigorous and proof-based treatment of functions of one real variable. The Real Number System: Field and order axioms, sups and infs, completeness, integers and rational numbers. Real Sequences: Limits, cluster points, limsup and liminf, subsequences, monotonic sequences, Cauchy's criterion, Bolzano-Weierstrass Theorem. Topology of the Real Line: Open sets, closed sets, density, compactness, Heine-Borel Theorem. Continuity: attainment of extrema, Intermediate Value Theorem, uniform continuity. Differentiation: Chain Rule, local extrema, Mean-Value Theorems, L'Hospital's Rule, Taylor's Theorem. Riemann Integration: Partitions, upper and lower integrals, sufficient conditions for integrability, Fundamental Theorem of Calculus. Sequences of Functions: Pointwise convergence, uniform convergence, interchanging the order of limits. The course presumes some mathematical sophistication including the ability to recognize, read, and write proofs. 3 hrs lec.

Prerequisites: 21-122 and 21-127

21-356 Principles of Real Analysis II

Spring: 9 units

This course provides a rigorous and proof-based treatment of functions of several real variables. Topology in metric spaces, specialization to finite dimensional normed linear spaces. Vector differential calculus: continuity and the total derivative, partial derivatives, directional derivatives, gradients, Jacobians, the chain rule, implicit function theorem. Vector integral calculus: double and triple integrals, arclength and surface area, line integrals, Green's Theorem, surface integrals, Divergence and Stokes Theorems. If time permits: trigonometric series, Fourier series for orthonormal bases, minimization of square error. The course presumes some mathematical sophistication including the ability to recognize, read, and write proofs. 21-268 or 21-269 are strongly recommended rather than 21-259. 3 hrs lec.

Prerequisites: (21-268 or 21-259 or 21-269) and 21-241 and 21-355

21-365 Projects in Applied Mathematics

Intermittent: 9 units

This course provides students with an opportunity to solve problems posed by area companies. It is also designed to provide experience working as part of a team to solve problems for a client. The background needed might include linear programming, simulation, data analysis, scheduling, numerical techniques, etc.

21-366 Topics in Applied Mathematics

Intermittent: 9 units

Typical of courses that might be offered from time to time are game theory, non-linear optimization, and dynamic programming. Prerequisites will depend on the content of the course. 3 hrs. lec.

Prerequisite: 21-127

21-369 Numerical Methods

Fall and Spring: 9 units

This course provides an introduction to the use of computers to solve scientific problems. Methods for the computational solution of linear algebra systems, nonlinear equations, the interpolation and approximation of functions, differentiation and integration, and ordinary differential equations. Analysis of roundoff and discretization errors and programming techniques. 21-268 or 21-269 are recommended rather than 21-259. 3 hrs. lec.

Prerequisites: (15-110 or 15-112) and (21-269 or 21-259 or 21-268) and (21-240 or 21-241 or 21-242) and (33-231 or 21-260 or 21-261)

21-370 Discrete Time Finance

Fall: 9 units

This course introduces the Black-Scholes option pricing formula, shows how the binomial model provides a discretization of this formula, and uses this connection to fit the binomial model to data. It then sets the stage for Continuous-Time Finance by discussing in the binomial model the mathematical technology of filtrations, martingales, Markov processes and risk-neutral measures. Additional topics are American options, expected utility maximization, the Fundamental Theorems of Asset Pricing in a multi-period setting, and term structure modeling, including the Heath-Jarrow-Morton model. Students in 21-370 are expected to read and write proofs. 3 hrs lec.

Prerequisites: (21-270 or 70-492) and (21-269 or 21-268 or 21-256 or 21-259)

Corequisites: 70-207 or 36-225 or 36-217 or 21-325

21-371 Functions of a Complex Variable

Intermittent: 9 units

This course provides an introduction to one of the basic topics of both pure and applied mathematics and is suitable for those with both practical and theoretical interests. Algebra and geometry of complex numbers; complex differentiation and integration. Cauchy's theorem and applications; conformal mapping; applications. 21-268 or 21-269 are recommended rather than 21-259. 3 hrs. lec.

Prerequisites: 21-235 or 21-355

21-372 Partial Differential Equations and Fourier Analysis

Spring: 9 units

This course provides an introduction to partial differential equations and is recommended for majors in mathematics, physical science, or engineering. Boundary value problems on an interval, Fourier series, uniform convergence, the heat, wave, and potential equations on bounded domains, general theory of eigenfunction expansion, the Fourier integral applied to problems on unbounded domains, introduction to numerical methods. 21-268 and 21-269 are recommended rather than 21-259; and 21-261 is recommended rather than 21-260. 3 hrs. lec.

Prerequisites: (21-259 or 21-268 or 21-269) and (21-261 or 21-260)

21-373 Algebraic Structures

Fall and Spring: 9 units

Groups: Homomorphisms. Subgroups, cosets, Lagrange's theorem. Conjugation. Normal subgroups, quotient groups, first isomorphism theorem. Group actions, Cauchy's Theorem. Dihedral and alternating groups. The second and third isomorphism theorems. Rings: Subrings, ideals, quotient rings, first isomorphism theorem. Polynomial rings. Prime and maximal ideals, prime and irreducible elements. PIDs and UFDs. Noetherian domains. Gauss' lemma. Eisenstein criterion. Fields: Field of fractions of an integral domain. Finite fields. Applications to coding theory, cryptography, number theory. 3 hrs lec.

Prerequisites: 21-127 and (21-241 or 21-242)

21-374 Field Theory

Spring: 9 units

The purpose of this course is to provide a successor to Algebraic Structures, with an emphasis on applications of groups and rings within algebra to some major classical problems. These include constructions with a ruler and compass, and the solvability or unsolvability of equations by radicals. It also offers an opportunity to see group theory and basic ring theory "in action", and introduces several powerful number theoretic techniques. The basic ideas and methods required to study finite fields will also be introduced. These ideas have recently been applied in a number of areas of theoretical computer science including primality testing and cryptography. 3 hrs. lec.

Prerequisite: 21-373

21-377 Monte Carlo Simulation for Finance

Intermittent: 9 units

A first course in Monte Carlo simulation, with applications to Mathematical Finance. Students will put into practice many of the theoretical ideas introduced in Continuous Time Finance. Topics to be covered: random variable/stochastic process generation; options pricing; variance reduction; Markov chain Monte Carlo Methods.

Prerequisites: 21-325 or 21-420

21-378 Mathematics of Fixed Income Markets

Fall: 9 units

A first course in fixed income. Students will be introduced to the most common securities traded in fixed income markets and the valuation methods used to price them. Topics covered include discount factors; interest rates basics; pricing of coupon bonds; identifying the yield to maturity, as well as bond sensitivities to interest rates; term structure modeling; forward and swap rates; fixed income derivatives (including mortgage backed securities) and their valuation through backwards induction; fixed income indexes and return attribution. For a co-requisite, 36-225 can be accepted as an alternative for 21-325.

Prerequisite: 21-270

Corequisites: 21-325 and 21-370

21-393 Operations Research II

Fall: 9 units

Building on an understanding of Linear Programming developed in 21-292 Operations Research I, this course introduces more advanced topics. Integer programming, including cutting planes and branch and bound. Dynamic programming. An introduction to Combinatorial Optimization including optimal spanning trees, shortest paths, the assignment problem and max-flow/min-cut. The traveling salesman problem and NP-completeness. An important goal of this course is for the student to gain experience with the process of working in a group to apply operations research methods to solve a problem. A portion of the course is devoted to a group project based upon case studies and the methods presented. 36-410 recommended. 3 hrs. lec.

Prerequisites: (15-251 or 21-228) and 21-292

21-400 Intermediate Logic

Spring: 9 units

The course builds on the proof theory and model theory of first-order logic covered in 21-300. These are applied in 21-400 to Peano Arithmetic and its standard model, the natural numbers. The main results are the incompleteness, undefinability and undecidability theorems of Gödel, Tarski, Church and others. Leading up to these, it is explained how logic is formalized within arithmetic, how this leads to the phenomenon of self-reference, and what it means for the axioms of a theory to be computably enumerable. Related aspects of computability theory are included to the extent that time permits.

Prerequisite: 21-300

21-420 Continuous-Time Finance

Spring: 9 units

This course begins with Brownian motion, stochastic integration, and Ito's formula from stochastic calculus. This theory is used to develop the Black-Scholes option pricing formula and the Black-Scholes partial differential equation. Additional topics may include models of credit risk, simulation, and expected utility maximization. 3 hrs lec.

Prerequisites: (18-202 or 21-260) and 21-370 and (21-325 or 36-217 or 36-225)

21-440 Selected Topics in Algebra

Intermittent: 9 units

Typical courses that might be offered from time to time are algebraic geometry, elliptic curves, commutative algebra, and theory of Boolean functions. The prerequisites will depend on the content of the course.

Prerequisite: 21-373

21-441 Number Theory

Fall: 9 units

Number theory deals with the integers, the most basic structures of mathematics. It is one of the most ancient, beautiful, and well-studied branches of mathematics, and has recently found surprising new applications in communications and cryptography. Course contents: Structure of the integers, greatest common divisors, prime factorization. Modular arithmetic, Fermat's Theorem, Chinese Remainder Theorem. Number theoretic functions, e.g. Euler's function, Möbius functions, and identities. Diophantine equations, Pell's Equation, continued fractions. Modular polynomial equations, quadratic reciprocity. 3 hrs. lec.

Prerequisites: (21-241 or 21-242) and 21-373

21-450 Topics in Geometry

Intermittent: 9 units

Typical of courses, which are offered from time to time are convex sets, projective geometry, and classical geometry. The prerequisites will depend on the content of the course. 3 hrs. lec.

21-465 Topology

Fall: 9 units

Metric spaces. Topological spaces. Separation axioms. Open, closed and compact sets. Continuous functions. Product spaces, subspaces, quotient spaces. Connectedness and path-connectedness. Homotopy. Fundamental group of a pointed space. Simply connected spaces. Winding number, the fundamental group of the circle. Functorial property of the fundamental group. Brouwer fixed point theorem. Covering spaces. van Kampen's theorem. 2-manifolds. Triangulations. Euler characteristic. Surgery, classification of compact 2-manifolds. 3 hrs lec.

Prerequisites: 21-355 and 21-373

21-467 Differential Geometry

9 units

This course will provide a thorough and rigorous introduction to differential geometry on manifolds. Contents: Differentiable manifolds; tangent spaces; vector fields and n-forms; integral curves; cotangent vectors; tensors; Riemannian metrics; connection; parallel transport; geodesics and convex neighborhoods; sectional, Ricci, scalar curvatures; tensors on Riemannian manifolds; Lie groups; transformation groups.

Prerequisites: 21-356 and 21-373

21-470 Selected Topics in Analysis

Intermittent: 9 units

Typical of courses, which are offered from time to time are finite difference equations, calculus of variations, and applied control theory. The prerequisites will depend on the content of the course. 3 hrs. lec.

Prerequisites: 21-241 and 21-259 and 21-260

21-476 Introduction to Dynamical Systems

Intermittent: 9 units

This course is an introduction to differentiable dynamical systems. The material includes basic properties of dynamical systems, including the existence and uniqueness theory, continuation, singular points, orbits, and their classification. The Poincaré-Bendixson theorem and typical applications, like Liénard equations and Lotka-Volterra are also covered. An introduction to chaos as time permits. 3 hrs. lec.

Prerequisites: (21-241 or 21-242) and 21-261

21-484 Graph Theory

Spring: 9 units

Graph theory uses basic concepts to approach a diversity of problems and nontrivial applications in operations research, computer science and other disciplines. It is one of the very few mathematical areas where one is always close to interesting unsolved problems. Topics include graphs and subgraphs, trees, connectivity, Euler tours and Hamilton cycles, matchings, graph colorings, planar graphs and Euler's Formula, directed graphs, network flows, counting arguments, and graph algorithms. 3 hrs. lec.
Prerequisites: (21-228 or 15-251) and (21-241 or 21-242)

21-499 Undergraduate Research Topic

Fall: 9 units

This course affords undergraduates to pursue elementary research topics in the area of expertise of the instructor. The prerequisites will depend on the content of the course.

21-590 Practicum

All Semesters

Students in this course gain experience with the application of mathematical models to business and/or industrial problems during an internship. The internship is set up by the student in consultation with a faculty member. The students must also have a mentor at the firm providing the internship, who together with the faculty member develops a description of the goals of the internship. The internship must include the opportunity to learn about problems which have mathematical content.

21-599 Undergraduate Reading and Research

Fall and Spring

Individual reading courses or projects in mathematics and its applications. Prerequisites and units to be negotiated with individual instructors.

21-600 Mathematical Logic I

Fall: 12 units

The study of formal logical systems, which model the reasoning of mathematics, scientific disciplines, and everyday discourse. Propositional Calculus and First-order Logic. Syntax, axiomatic treatment, derived rules of inference, proof techniques, computer-assisted formal proofs, normal forms, consistency, independence, semantics, soundness, completeness, Lowenheim-Skolem Theorem, compactness, equality. 3 hrs. lec.
Prerequisites: 21-373 or 21-228 or 21-484

21-602 Introduction to Set Theory I

Fall: 12 units

First order definability and the Zermelo-Fraenkel axioms; cardinal arithmetic, ordered sets, well-ordered sets (axiom of choice), transfinite induction, the filter of closed unbounded sets (Fodor, Ulm and Solovay's theorems), Delta systems, basic results in partition calculus (e.g., Ramsey's Theorem and the Erdos-Rado Theorem); small to medium large cardinals; applications to general topology (e.g., Alexandroff's conjecture), and the basic ideas of descriptive set theory. The independence of Suslin conjecture from the usual axioms. Godel's axiom of constructibility. Time permitting, the Galvin-Hajnal-Shelah inequality will be proved. 3 hrs. lec.

21-603 Model Theory I

Intermittent: 12 units

Similarity types, structures; downward Lowenheim Skolem theorem; construction of models from constants, Henkin's omitting types theory, prime models; elementary chains of models, basic two cardinal theorems, saturated models, basic results on countable models including Ryll-Nardzewski's theorem; indiscernible sequences, Ehrenfeucht-Mostowski models; introduction to stability, rank functions, primary models, and a proof of Morley's categoricity theorem; basic facts about infinitary languages, computation of Hanf-Morley numbers.

21-604 Introduction to Recursion Theory

Intermittent: 12 units

Models of computation, computable functions, solvable and unsolvable problems, reducibilities among problems, recursive and recursively enumerable sets, the recursion theorem, Post's problem and the Friedberg-Muchnik theorem, general degrees and r.e. degrees, the arithmetical hierarchy, the hyper-arithmetical hierarchy, the analytical hierarchy, higher type recursion. 3 hrs. lec.

21-610 Algebra I

Spring: 12 units

The structure of finitely generated abelian groups, the Sylow theorems, nilpotent and solvable groups, simplicity of alternating and projective special linear groups, free groups, the Nielsen-Schreier theorem. Vector spaces over division rings, field extensions, the fundamental Galois correspondence, algebraic closure. The Jacobson radical and the structure of semisimple rings. Time permitting, one of the following topics will be included: Wedderburn's theorem on finite division rings, Frobenius' Theorem. Prerequisite: Familiarity with the content of an undergraduate course on groups and rings. 3 hrs. lec.

21-620 Real Analysis

Fall: 6 units

A review of one-dimensional, undergraduate analysis, including a rigorous treatment of the following topics in the context of real numbers: sequences, compactness, continuity, differentiation, Riemann integration. (Mini-course. Normally combined with 21-621.) 3 hrs. lec.

21-621 Introduction to Lebesgue Integration

Fall: 6 units

Construction of Lebesgue measure and the Lebesgue integral on the real line. Fatou's Lemma, the monotone convergence theorem, the dominated convergence theorem. (Mini-course. Normally combined with 21-620.) 3 hrs. lec.

21-630 Ordinary Differential Equations

All Semesters: 12 units

Basic concepts covered are existence and uniqueness of solutions, continuation of solutions, continuous dependence, and stability. For autonomous systems, topics included are: orbits, limit sets, Liapunov's direct method, and Poincaré-Bendixson theory. For linear systems, topics included are: fundamental solutions, variation of constants, stability, matrix exponential solutions, and saddle points. Time permitting, one or more of the following topics will be covered: differential inequalities, boundary-value problems and Sturm-Liouville theory, Floquet theory.

21-640 Introduction to Functional Analysis

Spring: 12 units

Linear spaces: Hilbert spaces, Banach spaces, topological vector spaces. Hilbert spaces: geometry, projections, Riesz Representation Theorem, bilinear and quadratic forms, orthonormal sets and Fourier series. Banach spaces: continuity of linear mappings, Hahn-Banach Theorem, uniform boundedness, open-mapping theorem. Closed operators, closed graph theorem. Dual spaces: weak and weak-star topologies (Banach-Alaoglu Theorem), reflexivity. Space of bounded continuous functions and its dual. Linear operators and adjoints: basic properties, null spaces and ranges. Compact operators. Sequences of bounded linear operators: weak, strong and uniform convergence. Introduction to spectral theory: Notions of spectrum and resolvent set of bounded operators, spectral theory of compact operators. Time permitting: Fredholm Alternative. Time permitting: Stone-Weierstrass Theorem.
Prerequisites: 21-651 and (21-621 or 21-720)

21-651 General Topology

Fall: 12 units

Metric spaces: continuity, compactness, Arzela-Ascoli Theorem, completeness and completion, Baire Category Theorem. General topological spaces: bases and subbases, products, quotients, subspaces, continuity, topologies generated by sets of functions, homeomorphisms. Convergence: nets, filters, and the inadequacy of sequences. Separation: Hausdorff spaces, regular spaces, completely regular spaces, normal spaces, Urysohn's Lemma, Tietze's Extension Theorem. Connectedness. Countability conditions: first and second countability, separability, Lindelof property. Compactness: Tychonoff's Theorem, local compactness, one-point compactification. 3 hrs. lec.

21-660 Introduction to Numerical Analysis I

Spring: 12 units

Finite precision arithmetic, interpolation, spline approximation, numerical integration, numerical solution of linear and nonlinear systems of equations, optimization in finite dimensional spaces. 3 hrs. lec.

21-690 Methods of Optimization

Fall: 12 units

An introduction to the theory and algorithms of linear and nonlinear programming with an emphasis on modern computational considerations. The simplex method and its variants, duality theory and sensitivity analysis. Large-scale linear programming. Optimality conditions for unconstrained nonlinear optimization. Newton's method, line searches, trust regions and convergence rates. Constrained problems, feasible-point methods, penalty and barrier methods, interior-point methods.

21-700 Mathematical Logic II

Spring: 12 units

Higher-order logic (type theory). Syntax, Lambda-notation, Axioms of Description and Choice, computer-assisted formal proofs, semantics, soundness, standard and non-standard models, completeness, compactness, formalization of mathematics, definability of natural numbers, representability of recursive functions, Church's Thesis. Godel's Incompleteness Theorems, undecidability, undefinability.

Prerequisites: 21-300 or 21-600

Course Website: <http://gtps.math.cmu.edu/description-700.txt>**21-701 Discrete Mathematics**

Intermittent: 12 units

Combinatorial analysis, graph theory with applications to problems in computational complexity, networks, and other areas.

21-720 Measure and Integration

Spring: 12 units

The Lebesgue integral, absolute continuity, signed measures and the Radon-Nikodym Theorem, Lp spaces and the Riesz Representation Theorem, product measures and Fubini's Theorem.

21-721 Probability

All Semesters: 12 units

Probability spaces, random variables, expectation, independence, Borel-Cantelli lemmas. Kernels and product spaces, existence of probability measures on infinite product spaces, Kolmogorov's zero-one law. Weak and strong laws of large numbers, ergodic theorems, stationary sequences. Conditional expectation: characterization, construction and properties. Relation to kernels, conditional distribution, density. Filtration, adapted and predictable processes, martingales, stopping times, upcrossing inequality and martingale convergence theorems, backward martingales, optional stopping, maximal inequalities. Various applications of martingales: branching processes, Polya's urn, generalized Borel-Cantelli, Levy's 0-1 law, martingale method, strong law of large numbers, etc. Weak convergence of probability measures, characteristic functions of random variables, weak convergence in terms of characteristic functions. Central limit theorem, Poisson convergence, Poisson process. Large deviations, rate functions, Cramer's Theorem.

Prerequisite: 21-720

21-732 Partial Differential Equations I

All Semesters: 12 units

An introduction to the modern theory of partial differential equations. Including functional analytic techniques. Topics vary slightly from year to year, but generally include existence, uniqueness and regularity for linear elliptic boundary value problems and an introduction to the theory of evolution equations.

21-737 Probabilistic Combinatorics

All Semesters: 12 units

This course covers the probabilistic method for combinatorics in detail and introduces randomized algorithms and the theory of random graphs. Methods covered include the second moment method, the Rödl nibble, the Lovász local lemma, correlation inequalities, martingale's and tight concentration, Janson's inequality, branching processes, coupling and the differential equations method for discrete random processes. Objects studied include the configuration model for random regular graphs, Markov chains, the phase transition in the Erdős-Rényi random graph, and the Barabási-Albert preferential attachment model.

21-738 Extremal Combinatorics

All Semesters: 12 units

Classical problems and results in extremal combinatorics including the Turán and Zarankiewicz problems, the Erdős-Stone theorem and the Erdős-Simonovits stability theorem. Extremal set theory including the Erdős-Rado sunflower lemma and variations, VC-dimension, and Kneser's conjecture. The Szemerédi regularity lemma. Algebraic methods including finite field constructions and eigenvalues and expansion properties of graphs. Shannon capacity of graphs. Chromatic number of R_n and Borsuk's conjecture. Graph decomposition including Graham-Pollack and Baranyai's theorem.

21-901 Masters Degree Research

All Semesters

Missing Course Description - please contact the teaching department.

Mechanical Engineering Courses**24-101 Fundamentals of Mechanical Engineering**

Fall and Spring: 12 units

The purpose of this course is to introduce the student to the field of mechanical engineering through an exposition of its disciplines, including structural analysis, mechanism design, fluid flows, and thermal systems. By using principles and methods of analysis developed in lectures, students will complete two major projects. These projects will begin with conceptualization, proceed with the analysis of candidate designs, and culminate in the construction and testing of a prototype. The creative process will be encouraged throughout. The course is intended primarily for CIT freshmen. 3 hrs. lec., 2 hrs. rec./lab.

Corequisites: 21-120 and 33-106

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-200 Machine Shop Practice**

Fall and Spring: 1 unit

24-200 Machine Shop Practices Fall and Spring Semesters, 1 units, 6 week mini course This course familiarizes students with the operation and safety of machine tools. This gives students knowledge of what goes into engineering designs in building a prototype and also enables them to operate shop machinery as a part of future courses. Prerequisite: Undergraduate Mechanical Engineering standing 2 hours lab Machine Shop Practices should be completed prior to Design II 24-441. However, if necessary, it may be scheduled concurrently with Design II in the first mini of the semester.

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-201 Engineering Graphics**

Spring: 9 units

Introduction to the use and preparation of manually and computer generated engineering drawings, including the following topics: basic drawing techniques; dimensioning of orthographic drawings; auxiliary and oblique views; sectional drawings; working drawings; blueprint reading; freehand sketching; production standards, methods, and symbols; simplified drawing techniques; intersection and development; basic applied descriptive geometry. Free elective credit only- not acceptable as a Mechanical Engineering Technical Elective. 3 hrs. rec., 3 hrs. lab.

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-202 Introduction to Computer Aided Design**

Fall and Spring: 1 unit

Introduction to computer aided mechanical design using SolidWorks 3D CAD software. Includes the creation and analysis of components and assemblies, generation of drawings, and exporting for manufacture. Two hours of guided computer lab work each week. Prerequisite: Undergraduate Mechanical Engineering standing

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-210 Special Topics: Additive Manufacturing for Engineers**

Spring: 3 units

Introduction to additive manufacturing (AM) fundamentals and applications using Solidworks 3-D CAD software and a variety of polymer and metal AM machines. Includes a brief history of AM processing, a review of and technical fundamentals of current AM processes, a study of the current AM market, and future directions of the technology. Lab Sessions will support an open-ended design project. Completion of 24-202 Intro to CAD, is required.

24-221 Thermodynamics I

Fall: 10 units

Temperature and thermometry; equations of state for fluids and solids; work, heat, and the first law; internal energy, enthalpy, and specific heats; energy equations for flow; change of phase; the second law, reversibility, absolute temperature, and entropy; combined first and second laws; availability; power and refrigeration cycles. Applications to a wide range of processes and devices. 3 hrs. lec., 1 hour recitation

Prerequisites: 33-106 and 24-101 and (21-122 or 21-123)

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-231 Fluid Mechanics**

Spring: 10 units

Hydrostatics. Control volume concepts of mass, momentum, and energy conservation. Euler's and Bernoulli's equations. Viscous flow equations. Head loss in ducts and piping systems. Dimensional analysis and similitude as an engineering tool. Measurement techniques. 3 hrs. lec., 1 hr. rec. Prerequisites: 33-106 and (21-123 or 21-122)

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>

24-261 Statics

Fall: 10 units

This course is the first in a two-semester sequence on the solid mechanics of engineering structures and machines. The course begins with a review of the statics of rigid bodies, which includes the identification of statically indeterminate problems. Two- and three-dimensional statics problems are treated. Thereafter, the course studies stresses and deflections in deformable components. In turn, the topics covered are: simple tension, compression, and shear; thin-walled pressure vessels; torsion; and bending of beams. For each topic, statically indeterminate problems are analyzed and elementary considerations of strength are introduced. 3 hrs. lec., 1 hr. rec./lab.

Prerequisites: (21-122 or 21-123) and 33-106

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-262 Stress Analysis**

Spring: 12 units

This course is the second in a two-semester sequence on the solid mechanics of engineering structures and machines. The basic topics of uniaxial tension/compression, torsion, and flexural deformation from 24-261 are reviewed. Combined loadings and stresses are then treated, which lead to a consideration of failure criteria. Two-dimensional elasticity and the finite element method are introduced. Stress concentrations are quantified analytically, numerically, and with the use of engineering handbooks. Cyclic failure criteria are introduced, and both static and cyclic failure criteria are applied to results from numerical analysis. 3 hrs. lec., 1 hr. rec./lab.

Prerequisites: 33-106 and 24-261

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-292 Special Topics in Renewable Energy Engineering**

Intermittent: 9 units

Introduction to engineering principles of various renewable energy systems, including the following topics: background on climate change and carbon sequestration, engineering analysis of renewable energy systems such as solar photovoltaic, wind power, hydropower, wave energy, bio mass energy, geothermal energy, and hydrogen based fuel cells. In addition, transitional energy systems such as nuclear power and advanced combined cycles will be introduced. Both engineering performance and present state of development will be discussed. Students will be asked to study and present current progress on various subjects of particular interest to them.

Course Website: <http://www.cmu.edu/me/>**24-302 Mechanical Engineering Seminar I**

Fall and Spring: 2 units

The purpose of this course is to help students develop good presentation skills and to provide a forum for presentations and discussions of professional ethics. Students will make at least two presentations, one of which is related to professional ethics. Student grades will be based on their presentation skills and their participation in class discussions. 1 hr. rec.

Prerequisites: Junior standing or permission of instructor

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-311 Numerical Methods**

Spring: 12 units

Use of numerical methods for solving engineering problems with the aid of a digital computer. The course will contain numerical methods such as roots of equations, linear algebraic equations, optimization, curve fitting, integration, and differential equation solving. MATLAB will be used as the programming language. Programming cluster laboratory times will be available twice a week. Problems will be drawn from all fields of interest to mechanical engineers. 3 hrs. lecture plus lab

Prerequisite: 21-260

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-321 Thermal-Fluids Experimentation**

Spring: 12 units

24-321 Thermal-Fluids Experimentation Spring: 12 units This is a capstone course for the thermal-fluids core-course sequence. This course covers techniques of measurement, uncertainty analysis, and realization of systems, which demonstrate fundamental principles in thermodynamics, fluid mechanics, and heat transfer. The principles of designing thermal experiments are also integrated into this course.

Prerequisites: 24-231 and 24-221 and 24-322

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-322 Heat Transfer**

Fall: 10 units

Introduction to basic concepts of engineering heat transfer. Steady and transient heat conduction in solids, including the effect of heat generation. Finned surfaces. Correlation formulas for forced and free convection, condensation, and boiling. Design and analysis of heat exchangers. Radiation heat transfer. Problems in combined convection and radiation. Measurement techniques. 3 hrs. lec., 1 hr. recitation.

Prerequisites: 24-231 and 21-260 and 24-221

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-332 Potential Flow Aerodynamics**

Intermittent: 9 units

Development of the fundamental equations of incompressible frictionless flow. Concepts of circulation, vorticity, irrotationality, stream function, and velocity potential. Two-dimensional low speed airfoil theory; lift and moment calculations for the infinite span wing; empirical airfoil data for real airfoils; thin airfoil theory. Three-dimensional effects; flow distribution; Prandtl's wing theory; induced drag; the elliptic lift distribution; the general lift distribution. 3 hrs. rec.

Prerequisites: 24-231 and 21-260 and 21-259

Course Website: <http://www.andrew.cmu.edu/user/satbirs/24332/>**24-334 Introduction to Biomechanics**

Fall: 9 units

This course covers the application of solid and fluid mechanics to living tissues. This includes the mechanical properties and behavior of individual cells, the heart, blood vessels, the lungs, bone, muscle and connective tissues as well as methods for the analysis of human motion.

Prerequisite: 24-231

Course Website: <http://www.cmu.edu/me/>**24-341 Manufacturing Sciences**

Spring: 9 units

This course has two broad concerns: an introductory review of manufacturing systems organization and a review of common manufacturing processes from the point of view of design for manufacturability. The features of mass and batch production are quantitatively considered. The basic principles of group technology and production planning are outlined. The use of computers in manufacturing is described, together with a review of the current capabilities of industrial robots. Students will be involved in weekly seminars, which will describe the basic features of common manufacturing processes, including metal machining, metal forming, polymer processing, casting techniques, joining techniques, ceramic processing, and powder processing. Case studies from industry and films may be used. 3 hrs. rec.

Prerequisite: 24-262

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-351 Dynamics**

Fall: 10 units

This first course on the modeling and analysis of dynamic systems concentrates on the motion of particles, systems of particles, and rigid bodies under the action of forces and moments. Topics include the kinematics of motion in rectangular, polar, and intrinsic coordinates; relative motion analysis with multiple reference frames; and planar kinetics through the second law, work-energy method, and impulse-momentum method.

Time and frequency domain solutions to first and second order equations of motion are discussed. 3 hrs. lec. 1 hr rec.

Prerequisite: 24-261

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-352 Dynamic Systems and Controls**

Spring: 12 units

This second course on the modeling and analysis of dynamic systems emphasizes the common features, which are exhibited by physical systems that include mechanical, hydraulic, pneumatic, thermal, electrical, and electromechanical elements. State equations and the concepts of equilibrium, linearization, and stability are discussed. Time and frequency domain solutions are developed. 4 hr. lec.

Prerequisites: 24-261 and 33-107 and 21-260

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>

24-355 Kinematics and Dynamics of Mechanisms

Intermittent: 9 units

This design-oriented course addresses the kinematics and dynamics of mechanisms with applications to linkage systems, reciprocating engines, and industrial machinery. Conventional as well as innovative rigid-body dynamic systems are studied. Problems of kinematics and dynamics are framed in a form suited for computer analysis. The course bridges analysis and design by emphasizing the synthesis of mechanisms. To stimulate a creative approach, homework and project work draw upon actual engineering design problems. 3 hrs. rec.
Prerequisite: 24-351

24-358 Special Topics in Culinary Mechanics

Intermittent: 9 units

This course discusses how mechanical quantities and processes such as force, motion, and deformation influence food and the culinary arts. The aim of the course is to apply important aspects of mechanics to ideas in cooking. Specific topics include: (1) how do stress and strain affect food and its perceived taste; (2) what is the role of cell mechanics in the resulting micro structure of both consumed plant and animal tissues; (3) how can mechanics be used to alter nutrition; (4) what are the roles of common and uncommon mechanical tools such as a knife or mortar and pestle in food preparation. Emphasis will be placed on the biomechanics of edible matter across multiple length scales, including at the tissue, cellular, and molecular levels; additionally, impact on global health and engineering implications will be elucidated. During this course, we will introduce you to these concepts, train you to use them in real world applications, and allow you to pursue a creative group-defined project, which will be shared in both written and oral formats. We will integrate a hands-on kitchen experience in at least 3 specific laboratory classes so that students will get a true feel and understanding for culinary mechanics. We also will be visiting the restaurant of at least one first-rate Pittsburgh chef to gain real world insight into mechanics and cooking.

Course Website: <http://www.cmu.edu/me/>**24-361 Intermediate Stress Analysis**

Intermittent: 10 units

This course first reviews important solutions from strength of materials, Mohr's circle, and multiaxial failure theories. Students are then introduced to the theory of elasticity with an emphasis on understanding the field equations and boundary conditions. A short introduction to the theory of finite element methods is given. Additional topics covered include buckling, stress concentrations, plasticity, and fracture mechanics. An important aspect of the course is teaching students how topics covered in class can be applied to predict or understand failures in engineering applications. Another important skill that is emphasized is the application of fundamentals from the lectures and physical intuition to interpret results generated by finite element models. 3 hrs. lec., 1 hr. lab.
Prerequisites: 24-262 and 21-259

Course Website: <http://www.cmu.edu/me/>**24-370 Engineering Design I: Methods and Skills**

Fall: 12 units

24-370 Engineering Design I: Methods and Skills Spring: 12 Units In this course, students will learn methods and skills for the engineering design process, consisting of four stages: concept design, detail design, analysis, and manufacturing. The course covers the engineering design process in a holistic fashion by discussing theories and practices of the four stages and inter-relating them. Hands-on assignments, including computational and physical projects, are given to enhance the learning outcome. After taking this course, students will be able to: express ideas in sketches; interpret and create engineering drawings; select and apply machine elements; model detailed shapes with CAD tools; analyze product performance with CAE tools; choose materials and manufacturing schemes, and create and test prototypes. Recommended: 24-200 (machine shop practice). Prerequisite-24-202 Introduction to Computer Aided Design, 24-262 (stress analysis). Prerequisite: 24-262

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-391 Mechanical Engineering Project**

Fall and Spring

Practice in the organization, planning, and execution of appropriate engineering projects. These investigations may be assigned on an individual or a team basis and in most cases will involve experimental work. 9 hrs. lab.

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-392 Mechanical Engineering Project**

All Semesters

Practice in the organization, planning, and execution of appropriate engineering projects. These investigations may be assigned on an individual or a team basis and in most cases will involve experimental work. 9 hrs. lab.

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-421 Internal Combustion Engines**

Fall: 12 units

This course discusses working principles of internal combustion engines found in many practical applications. Focus is given to understanding the design of air handling system, in-cylinder fuel/air mixing, geometric design of the combustion chamber, engine performance and calibration, and mechanism of pollutant formation and reduction. Introductory discussion of advanced automotive engine concepts, alternative fuels, gas turbine engines, rocket engines, and hybrid electric vehicles is also provided. The course relies on a number of lab experiments, analysis of actual experimental data, and a combination of analytical and numerical homework assignments. 24-231 and 24-221 or equivalent 3 hrs. lecture 2 hrs. lab

Prerequisites: 24-231 and 24-221

Corequisite: 24-322

Course Website: <http://www.andrew.cmu.edu/user/satbirs/24421/>**24-424 Energy and the Environment**

Fall: 9 units

Fuel cycles for conventional and non-conventional energy resources; relationships between environmental impacts and the conversion or utilization of energy; measures of system and process efficiency; detailed study and analysis of coal-based energy systems including conventional and advanced power generation, synthetic fuels production, and industrial processes; technological options for multi-media (air, water, land) pollution control; mathematical modeling of energy-environmental interactions and tradeoffs and their dependency on technical and policy parameters; methodologies for energy and environmental forecasting; applications to issues of current interest. Junior or Senior standing in CIT or permission of instructor. 3 hrs lecture

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-425 Combustion and Air Pollution Control**

Intermittent: 9 units

Formation and control of gaseous and particulate air pollutants in combustion systems. Basic principles of combustion, including thermochemical equilibrium, flame temperature, chemical kinetics, hydrocarbon chemistry, and flame structure. Formation of gaseous and particulate pollutants in combustion systems. Combustion modifications and post-combustion technologies for pollutant control. Relationship between technology and regional, national, and global air pollution control strategies. The internal combustion engine and coal-fired utility boiler are used as examples. 3 hours lecture Cross listed as 24-740 and 19440/19-740

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-441 Engineering Design II: Conceptualization and Realization**

Fall and Spring: 12 units

24-441 - Engineering Design II: Conceptualization and Realization Fall and Spring 12 units. This course guides students through the design process in the applied design of a practical mechanical system. Lectures describe the typical design process and its associated activities, emphasizing methods for innovation and tools for design analysis. Professional and ethical responsibilities of designers, interactions with clients and other professionals, regulatory aspects, and public responsibility are discussed. The design project is typically completed in teams and is based on a level of engineering knowledge expected of seniors. Proof of practicality is required in the form of descriptive documentation. Frequently, a working model will also be required. Oral progress reports and a final written and oral report are required. 3 hrs. rec., 3 hrs lab Senior standing and Machine Shop Practice 24-200 required.

Prerequisites: 24-370 and 24-262

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>

24-451 Feedback Control Systems

Fall: 12 units

Fundamentals of feedback control with emphasis on classical techniques and an introduction to discrete-time (computer controlled) systems. Topics include the following: frequency domain modeling and state space modeling of dynamical systems; feedback control system concepts and components; control system performance specifications such as stability, transient response, and steady state error; analytical and graphical methods for analysis and design - root locus, Bode plot, Nyquist criterion; design and implementation of proportional, proportional-derivative, proportional-integral-derivative, lead, lag, and lead-lag controllers. Extensive use of computer aided analysis and design software. 4 hrs lec. Prerequisites: (15-110 or 15-112) and 24-352

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-452 Mechanical Systems Experimentation**

Fall: 9 units

24-452 Mechanical Systems Experimentation Fall : 9 Units Experimentation in dynamic systems and controls. The course will cover translational and rotational systems. Topics will include mechanical elements, natural frequencies, mode shapes, free and forced response, frequency response and Bode plots, time constants, transient response specifications, feedback controls such as PID control, and stability for single-degree-of-freedom and multi-degree-freedom systems. The course will introduce and use state-of-the-art experimentation hardware and software. 1 hr. lecture, 2 hrs. lab. 24-352 Dynamic Systems and Controls- prerequisite- MSE is a fall only senior course. Prerequisite: 24-352

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-491 Department Research Honors**

Fall and Spring

This course is designed to give students increased exposure to "open-ended" problems and research type projects. It involves doing a project on a research or design topic and writing a thesis describing that project. The project would be conducted under the supervision of a mechanical engineering faculty member (the advisor), and must be approved by the advisor before inception. This course can be taken at any time after the Junior year and before graduation which includes the summer after the Junior year. Completion of 18 units of this course with a grade of B or better is a partial fulfillment of the requirements for Departmental Research Honors.

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-492 Department Research Honors**

Fall and Spring

This course is designed to give students increased exposure to "open-ended" problems and research type projects. It involves doing a project on a research or design topic and writing a thesis describing that project. The project would be conducted under the supervision of a mechanical engineering faculty member (the advisor), and must be approved by the advisor before inception. This course can be taken at any time after the Junior year and before graduation which includes the summer after the Junior year. Completion of 18 units of this course with a grade of B or better is a partial fulfillment of the requirements for Departmental Research Honors.

Course Website: <http://www.cmu.edu/me/undergraduate/index.html>**24-612 Cardiovascular Mechanics**

Spring: 12 units

The primary objective of the course is to learn to model blood flow and mechanical forces in the cardiovascular system. After a brief review of cardiovascular physiology and fluid mechanics, the students will progress from modeling blood flow in a.) small-scale steady flow applications to b.) small-scale pulsatile applications to c.) large-scale or complex pulsatile flow applications. The students will also learn how to calculate mechanical forces on cardiovascular tissue (blood vessels, the heart) and cardiovascular cells (endothelial cells, platelets, red and white blood cells), and the effects of those forces. Lastly, the students will learn various methods for modeling cardiac function. When applicable, students will apply these concepts to the design and function of selected medical devices (heart valves, ventricular assist devices, artificial lungs). Prerequisite: 24-231

24-614 Microelectromechanical Systems

Intermittent: 12 units

This course introduces fabrication and design fundamentals for Microelectromechanical Systems (MEMS): on-chip sensor and actuator systems having micron-scale dimensions. Basic principles covered include microstructure fabrication, mechanics of silicon and thin-film materials, electrostatic force, capacitive motion detection, fluidic damping, piezoelectricity, piezoresistivity, and thermal micromechanics. Applications covered include pressure sensors, micromirror displays, accelerometers, and gas microsensors. Grades are based on exams and homework assignments. 4 hrs. lecture Prerequisite for undergraduates: 18-321 or 24-351 Prerequisite for: 18-724/24-724. Cross-listed 18-614. Prerequisites: 18-321 or 24-351

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-615 Microfluidics**

Intermittent: 12 units

This course offers an introduction to the emerging field of microfluidics with an emphasis on chemical and life sciences applications. During this course students will examine the fluid dynamical phenomena underlying key components of "lab on a chip" devices. Students will have the opportunity to learn practical aspects of microfluidic device operation through hands-on laboratory experience, computer simulations of microscale flows, and reviews of recent literature in the field. Throughout the course, students will consider ways of optimizing device performance based on knowledge of the fundamental fluid mechanics. Students will explore selected topics in more detail through a semester project. Major course topics include pressure-driven and electrokinetically-driven flows in microchannels, surface effects, micro-fabrication methods, micro/nanoparticles for biotechnology, biochemical reactions and assays, mixing and separation, two-phase flows, and integration and design of microfluidic chips. Undergraduate Fluid Mechanics prerequisite or instructor permission 4 hrs. lecture Prerequisite: 24-231

Course Website: <http://www.cmu.edu/me/graduate>**24-616 Tribology-Friction, Lubrication and Wear**

Intermittent: 12 units

24-616 - Tribology Friction, Lubrication and Wear Intermittent: 12 units Covers the science of surfaces interacting via dry, lubricated, and mixed (i.e., dry + lubricated) contact. Fundamental aspects include the Reynolds Equation, thermal-tribology, friction, and wear. Applied topics include bearings, surface analysis, nanomanufacturing, and biotribology. The course will conclude with a team project which will require computer programming. 4 hrs lec. Prerequisite: None Prerequisites: 24-262 and 24-322 and 24-231

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-618 Special Topics: Computational Analysis of Transport Phenomena**

Spring: 12 units

In this course, students will develop basic understanding and skill sets to perform simulations of transport phenomena (mass, momentum, and energy transport) for engineering applications using a CAE tool, learn to analyze and compare simulation results with theory or available data, and develop ability to relate numerical predictions to behavior of governing equations and the underlying physical system. First 8 weeks of the course will include lectures and simulation-based homework assignments. During last 7 weeks, teams of students will work on self-proposed projects related to computational analysis of transport phenomena. In the project, students will learn to approach loosely defined problems through design of adequate computational mesh, choice of appropriate numerical scheme and boundary conditions, selection of suitable physical models, efficient utilization of available computational resources etc. Each team will communicate results of their project through multiple oral presentations and a final written report.

Prerequisites: 24-322 and 24-221 and 24-231

Course Website: <http://www.andrew.cmu.edu/user/satbirs/24618/>

24-623 Molecular Simulation of Materials

Intermittent: 12 units

24-623: Molecular Simulation of Materials Spring: 12 units The purpose of this course is to expose engineering students to the theory and implementation of numerical techniques for modeling atomic-level behavior. The main focus is on molecular dynamics and Monte Carlo simulations. Students will write their own simulation computer codes, and learn how to perform calculations in different thermodynamic ensembles. Consideration will be given to heat transfer, mass transfer, fluid mechanics, mechanics, and materials science applications. The course assumes some knowledge of thermodynamics and computer programming. 4 hrs lec. Prerequisite: None
Prerequisites: 24-311 and 24-221

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-626 Air Quality Engineering**

Intermittent: 12 units

The course provides a quantitative introduction to the processes that control atmospheric pollutants and the use of mass balance models to predict pollutant concentrations. We survey major processes including emission rates, atmospheric dispersion, chemistry, and deposition. The course includes discussion of basic atmospheric science and meteorology to support understanding air pollution behavior. Concepts in this area include vertical structure of the atmosphere, atmospheric general circulation, atmospheric stability, and boundary layer turbulence. The course also discusses briefly the negative impacts of air pollution on society and the regulatory framework for controlling pollution in the United States. The principles taught are applicable to a wide variety of air pollutants but special focus is given to tropospheric ozone and particulate matter. The course is intended for graduate students as well as advanced undergraduates. It assumes a knowledge of mass balances, fluid mechanics, chemistry, and statistics typical of an undergraduate engineer but is open to students from other scientific disciplines. 12 units
Prerequisites: 36-220 and 24-231 and 09-105

Course Website: <http://www.cmu.edu/me/>**24-628 Energy Transport and Conversion at the Nanoscale**

Spring: 12 units

Energy transport and conversion processes occur at the nanoscale due to interactions between molecules, electrons, phonons, and photons. Understanding these processes is critical to the design of heat transfer equipment, thermoelectric materials, electronics, light emitting diodes, and photovoltaics. The objective of this course is to describe the science that underlies these processes and to introduce the contemporary experimental and theoretical tools used to understand them. 4 hrs. lecture Prerequisites-24-322 & 24-221 or equivalents
Prerequisites: 24-221 and 24-322

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-629 Direct Solar and Thermal Energy Conversion**

Intermittent: 12 units

This course introduces graduates and senior undergraduates the principles and technologies for directly converting heat and solar light into electricity using solid-state devices. The first part of the course reviews the fundamentals of quantum mechanics, solid state physics and semiconductor device physics for understanding solid-state energy conversion. The second part discusses the underlying principles of thermoelectric energy conversion, thermionic energy conversion, and photovoltaics. Various solar thermal technologies will be reviewed, followed by an introduction to the principles of solar thermophotovoltaics and solar thermoelectrics. Spectral control techniques which are critical for solar thermal systems will also be discussed. By applying the basic energy conversion theory and principles covered in lectures, students will finish a set of 4 homework assignments. This course also requires one project in which students will work individually to review one present solar or thermal energy conversion technology 12 units

Course Website: <http://www.cmu.edu/me/>**24-642 Fuel Cell Systems**

Fall: 12 units

Fuel cells are devices that convert chemical potential energy directly into electrical energy. Existing fuel cell applications range from the small scale, such as portable cell phone chargers, to the large scale, such as MW-scale power plants. Depending on the application, fuel cell systems offer unique advantages and disadvantages compared with competing technologies. For vehicle applications, they offer efficiency and environmental advantages compared with traditional combustion engines. In the first half of the course, the focus is on understanding the thermodynamics and electrochemistry of the various types of fuel cells, such as calculating the open circuit voltage and the sources of voltage loss due to irreversible processes for the main fuel cells types: PEM/SOFC/MCFC. The design and operation of several real fuel cells are then compared against this theoretical background. The second half of the course focuses on the balance-of-plant requirements of fuel cell systems, such as heat exchangers, pumps, fuel processors, compressors, as well as focusing on capital cost estimating. Applying the material learned from the first and second halves of the class into a final project, students will complete an energy & economic analysis of a fuel cell system of their choice. Prerequisite- Undergraduate Thermodynamics course 12 units
Prerequisites: 06-221 or 24-221 or 27-215

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-650 Special Topics in Applied Finite Element Analysis**

Intermittent: 12 units

This is an introductory course for the finite element method with emphasis on application of the method to a wide variety of problems. The theory of finite element analysis is presented and students learn various applications of the method through labs using ANSYS. Various types of analyses are considered including static, pseudo-static, dynamic, modal, buckling, contact, heat transfer, thermal stress and thermal shock. The students use truss, beam, spring, solid, plate, and shell elements in the models created. Prerequisites: 24-322 and 24-262

24-651 Special Topics in Material Selection for Mechanical Engineers

Spring: 12 units

This course provides a methodology for selecting materials for a given application. It aims to provide an overview of the different classes of materials (metal, ceramic, glass, polymer, elastomer or hybrid) and their properties including modulus, strength, ductility, toughness, thermal and electrical conductivity, and resistance to corrosion in various environments. Students will also learn how materials are processed and shaped (e.g., injection molding, casting, forging, extrusion, welding, grinding, and polishing), and will explore the origins of the properties, which vary by orders of magnitude. The course accomplishes the materials selection objective in part through example applications and in part through the use of CES EduPack software (a visual way to explore the world of materials and processes). Topics include: Materials selection by stiffness, weight, strength, fracture toughness, corrosion and oxidation, and thermal properties. Materials at high temperatures, materials shaping. Phase diagrams and phase transformations.
Prerequisites: 09-105 and 24-262

24-655 Cellular Biomechanics

Intermittent: 9 units

Cellular Biomechanics Intermittent: 9 units This course discusses how mechanical quantities and processes such as force, motion, and deformation influence cell behavior and function, with a focus on the connection between mechanics and biochemistry. Specific topics include: (1) the role of stresses in the cytoskeleton dynamics as related to cell growth, spreading, motility, and adhesion; (2) the generation of force and motion by moot molecules; (3) stretch-activated ion channels; (4) protein and DNA deformation; (5) mechanochemical coupling in signal transduction. If time permits, we will also cover protein trafficking and secretion and the effects of mechanical forces on gene expression. Emphasis is placed on the biomechanics issues at the cellular and molecular levels; their clinical and engineering implications are elucidated. 3 hrs. lec. Prerequisite: Instructor permission.

Course Website: <http://www.cmu.edu/me/graduate/index.html>

24-656 Advanced Manufacturing

Intermittent: 12 units

24-656 Advanced Manufacturing Intermittent: 12 units This course focuses on modeling of material removal processes, including the turning, milling, boring, and drilling processes. The course also includes introduction on economics of material removal, non-traditional material removal processes, stability of machining processes, tool wear and tool life, dimensional and surface metrology, and experimental methods in manufacturing. A term project that may involve experimentations is an integral part of the course. 4 hrs lec. Prerequisite: Senior or Graduate Standing

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-657 Molecular Biomechanics**

Intermittent: 9 units

This class is designed to present concepts of molecular biology, cellular biology and biophysics at the molecular level together with applications. Emphasis will be placed both on the biology of the system and on the fundamental physics, chemistry and mechanics which describe the molecular level phenomena within context. In addition to studying the structure, mechanics and energetics of biological systems at the nano-scale, we will also study and conceptually design biomimetic molecules and structures. Fundamentals of DNA, globular and structured proteins, lips and assemblies thereof will be covered.

Prerequisites: 06-221 and 24-221

Course Website: <http://www.cmu.edu/me>**24-658 Computational Bio-Modeling and Visualization**

Spring: 12 units

Biomedical modeling and visualization play an important role in mathematical modeling and computer simulation of real/artificial life for improved medical diagnosis and treatment. This course integrates mechanical engineering, biomedical engineering, computer science, and mathematics together. Topics to be studied include medical imaging, image processing, geometric modeling, visualization, computational mechanics, and biomedical applications. The techniques introduced are applied to examples of multi-scale biomodeling and simulations at the molecular, cellular, tissue, and organ level scales. 4 hrs. lec./lab

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-661 Vibrations of Linear and Dynamic Systems**

Intermittent: 12 units

The subject area for this course is mechanical vibration, at a level appropriate for first-year graduate students. Classical techniques in mechanical vibration are developed for the modeling and analysis of discrete and continuous linear systems. Continuous systems are described within the broader context of operator theory to emphasize the physical and mathematical analogies with discrete systems. Specific topics include: Discrete systems. Equations of motion for multiple degree of freedom systems through Lagrange's method; linearization about equilibrium; symmetry and definiteness properties; free vibration; matrix eigenvalue problems; orthogonality; Rayleigh quotient; generalized coordinates; transient and forced response through modal analysis. Continuous systems. Classical rod, shaft, string, beam, membrane and plate models; Hamilton's principle; equations of motion and boundary conditions through variational methods; essentials of functional analysis; exact solution of eigenvalue problems; response through modal analysis and Green's function methods; global discretization; Galerkin's method; essential and suppressible boundary conditions; Kamke quotient; introduction to elastic wave propagation. Lecture 4.0 hours

Course Website: <http://www.cmu.edu/me/>**24-672 Special Topics in DIY Design and Fabrication**

Fall: 12 units

The traditional principles of mass production are being challenged by concepts of highly customized and personalized goods. A growing number of do-it-yourself (DIY) inventors, designers, makers, and entrepreneurs is accelerating this trend. This class offers students hands-on experiences of DIY product design and fabrication processes. Over the course of a semester, students work individually or in small groups to design a customized and personalized product of their own and build it using various DIY fabrication methods, including 3D laser scanning, 3D printing, laser cutting, vacuum forming, etc. Students develop multiple prototypes throughout the semester, iterating and refining their design.

Course Website: <https://www.andrew.cmu.edu/course/24-672/>**24-673 Soft Robots: Mechanics, Design and Modeling**

Spring: 12 units

Soft, elastically-deformable machines and electronics will dramatically improve the functionality, versatility, and biological compatibility of future robotic systems. In contrast to conventional robots and machines, these ? soft robots? will be composed of elastomers, gels, fluids, gas, and other non-rigid matter. We will explore emerging paradigms in soft robotics and study their design principles using classical theories in solid mechanics, thermodynamics, and electrostatics. Specific topics include artificial muscles, peristaltic robotics, soft pneumatic robotics, fluid-embedded elastomers, and particle jamming. This course will include a final project in which students may work individually or as a team. For the project, students are expected to design and simulate and/or build all or part (eg. sensors, actuators, grippers, etc.) of a soft robot. Prerequisites: Statics and Stress Analysis or equivalents.

Prerequisite: 24-262

Course Website: <http://www.cmu.edu/me/>**24-674 Design of Biomechatronic Systems for Humans**

Intermittent: 12 units

This course explores methods for the design of electromechanical devices that physically interface with humans to improve biomechanical performance, such as robotic prostheses and exoskeletons. Students will learn about common physical disabilities and methods for generating and evaluating potential interventions. Students will learn about state-of-the-art actuation and sensing systems, and design selected types to meet dynamic performance criteria. We will cover technology for interfacing these devices with humans, and implications for the resulting biomechatronic systems. Students will learn experimental methods for evaluating intervention effectiveness, including inverse dynamics and metabolics analyses. Students will complete a final project that involves introduction of novel elements to a biomechatronic system. Students need a foundation in machine design and numerical tools such as Matlab, and will benefit from knowledge of dynamics and biomechanics. Lecture 4 hrs. 12 units

Prerequisites: 24-370 and 24-351 and 24-311

Course Website: <http://www.cmu.edu/me/>**24-680 Quantitative Entrepreneurship: Analysis for New Technology Commercialization**

Intermittent: 12 units

This course provides engineers with a multidisciplinary mathematical foundation for integrated modeling of engineering design and enterprise planning decisions in an uncertain, competitive market. Topics include economics in product design, manufacturing and operations modeling and accounting, consumer choice modeling, survey design, conjoint analysis, decision-tree analysis, optimization, model integration and interpretation, and professional communication skills. Students will apply theory and methods to a team project for a new product or emerging technology, developing a business plan to defend technical and economic competitiveness. This course assumes fluency with basic calculus, linear algebra, and probability theory.

Prerequisite: 21-259

24-681 Computer-Aided Design

Intermittent: 12 units

24-681 Computer Aided Design Intermittent: 12 units This course is the first section of the two-semester sequence on computational engineering. Students will learn how computation and information technologies are rapidly changing the way engineering design is practiced in industry. The course covers the theories and applications of the measurement, representation, modeling, and simulation of three-dimensional geometric data used in the engineering designed process. Students taking this course are assumed to have knowledge of the first course in computer programming. 4 hrs lecture, 2 hrs computer cluster

Corequisite: 24-311

Course Website: <http://www.andrew.cmu.edu/course/24-681/>**24-682 Computer-Aided Engineering**

Intermittent: 12 units

24-682 Computer Aided Engineering Intermittent: 12 units This course is the second in the two-semester sequence on computational engineering. Students will learn how computation and information technologies are rapidly changing the way engineering analysis is practiced in industry. The course covers the theories and applications of finite element methods, finite element mesh generation, robot manipulator kinematics, and inverse kinematics, and manufacturing process optimization. Students taking this course are assumed to have knowledge of the first course in computer programming. 4 hrs lecture, 2 hrs computer cluster

Corequisite: 24-311

Course Website: <http://www.cmu.edu/me/graduate/index.html>

24-683 Design for Manufacture and the Environment

Fall: 12 units

Design for Manufacturing and the Environment examines influences of manufacturing and other traditionally downstream issues on the overall design process. Manufacturing is one facet that will be examined. Other downstream influences that will be studied include: assembly, robustness and quality, platform design, maintenance and safety, economics and costing, lean manufacturing and globalization. In addition, a core part of the course will focus on environment-based design issues. The class will study basic fundamentals in each of these areas and how they affect design decisions. Prerequisites: Senior standing in mechanical engineering, or permission of instructor

Course Website: <http://www.cmu.edu/me/graduate/index.html>**24-688 Introduction to CAD and CAE Tools**

Fall: 12 units

This course offers the hands-on training on how to apply modern CAD and CAE software tools to engineering design, analysis and manufacturing. In the first section, students will learn through 7 hands-on projects how to model complex free-form 3D objects using commercial CAD tools. In the second course of the sequence (24-681), if enrolled students will learn through 7 hands-on projects how to simulate complex multi-physics phenomena using commercial CAE tools. Units: 12 Format: 2 hrs. Lec., 2 hrs. computer lab

Prerequisites: 24-231 and 24-262

Corequisite: 24-351

Course Website: <http://www.cmu.edu/me/>**24-689 Special Topics: Global and Regional Sustainable Design**

Intermittent: 12 units

Engineers face unique challenges in a globalized and rapidly changing world, where decisions should be made so that our environment is preserved, social justice is promoted, and the needs of all people are provided through the global economy. Through the design activity, engineers creatively produce technical solutions to global challenges, such as depletion of resources, environmental pollution, rapid population growth and damage to ecosystems. In this project-based course students will learn about life cycle analysis, design sustainability, design for extreme affordability, socio-economic and cultural diversity considerations while working on a community-based project to design a mechanical technical product solution.

Military Science-ROTC Courses**30-101 Introduction to Military Leadership**

Fall: 5 units

In this course, students will be introduced to the fundamentals of Army leadership, management and basic military skills. The course emphasizes the Army's "Principles of Leadership" and familiarizes the student with rifle marksmanship, orienteering and map reading, rappelling, basic lifesaving skills and the wear of the Army uniform. In addition, students will enhance their time management, decision-making and physical fitness abilities. Each student must participate in physical training, field training exercises and is expected to wear the Army uniform, which will be provided.

30-102 Foundations of Leadership

Spring: 5 units

This course is a continuation of the subjects and skills taught in 30101. In addition to extending the student's abilities in the areas of leadership, orienteering and map reading, lifesaving and other basic military concepts, the course also introduces the student to the employment of military units. Individual topics covered include the Army's emerging technological enhancements, the Army organization and structure and the wartime policies and principles. Each student must participate in physical training, field training exercises and is expected to wear the Army uniform, which will be provided.

30-201 Leadership Dynamics and Application

Fall: 5 units

In this course, students will delve more deeply into the Army's leadership and management techniques, including the application of those techniques in faculty-supervised practical exercises. The course also seeks to enhance the student's abilities in orienteering and map reading, terrain analysis, advanced lifesaving techniques and physical fitness. Students are introduced to the values that define the United States Army as an American institution, and each student continues to enhance his or her physical development under the supervision of the faculty. Each student must participate in physical training, field training exercises and is expected to wear the Army uniform, which will be provided.

30-202 Applications in Leadership and Combat Power

Spring: 5 units

This course continues the study of the topics covered in 30201 and focuses upon practical application of the leadership and management techniques learned in the fall semester. The student develops and applies advanced map reading, terrain analysis, problem-solving and decision-making skills in practical exercises. Additionally, the student is introduced to the Army's formal orders process, used to maneuver and sustain Army forces on the modern battlefield. Each student must participate in physical training, field training exercises and is expected to wear the Army uniform, which will be provided.

30-205 Self Development Survey Skills

All Semesters: 3 units

Self Dev Sury Skills

30-301 Basic Leader Planning and Combat Operations

Fall: 5 units

This course offers an in-depth analysis and focused practical application of leadership and management techniques. The emphasis in the course is on leader development and the goal is to enhance the student's ability to perform effectively in a stressful decision-making environment. As such, time management, decision-making, advanced military skills, troop-leading procedures and advanced physical training are emphasized. The course requires participation in a demanding physical training program to prepare contracted students for the Army's R.O.T.C. Leader Development and Assessment Course (LDAC). Each student must participate in field training exercises and is expected to wear the Army uniform, which will be provided. Prerequisites: Class is open only to contracted students. Veterans with two or more years of service may enroll with approval.

30-302 Advanced Leader Planning and Combat Operations

Spring

This course builds upon the foundation laid in the fall semester with the objective of fully preparing contracted students for participation in the Army's challenging R.O.T.C. Leader Development and Assessment Course (LDAC). The course extends and enhances the student's leadership, management, communication, fitness and basic military skills in preparing the student for commissioning as an officer in the United States Army. Practical exercises are used to reinforce all of the skills that the student has developed over the course of the military science instruction. Each student must participate in physical training, field training exercises and is expected to wear the Army uniform, which will be provided. Prerequisites: Class is open only to contracted students. Veterans with two or more years of service may enroll with approval.

30-401 Progressive Leadership Theory and Applications

Fall: 5 units

This course is the first of two semester courses that serve as a capstone designed to transition the student from cadet to U.S. Army officer. Students are assigned to command and staff positions within the cadet battalion, corresponding to those found in United States Army units. Students perform the duties of the staff or command as assigned and interact with the other cadets as part of a functioning command organization. In addition to studying the operations and organizations of the U.S. Army, students are required to plan and execute the required training and activities in leading the underclass cadets. A variety of topics of current interest are covered. Guest speakers are commonly invited to discuss their military experiences or their perspectives on military-related topics. Each student must participate in physical training, field training exercises and is expected to wear the Army uniform, which will be provided. Prerequisites: Class is open only to contracted students.

30-402 Transition to the Profession of Arms

Spring: 5 units

This capstone course completes the transition from cadet to Army officer and concludes with the student's commissioning into the United States Army. During the semester, students continue to act in accordance with their assigned staff and command responsibilities and they prepare for their duties as a Lieutenant in the Army. This course covers personal and performance counseling, evaluation of subordinate leaders and team-building skills as well as military justice and discipline. Students bring to bear all of the skills and knowledge that they have accrued over the prior semesters in the Department of Military Science. Each student must participate in physical training, field training exercises and is expected to wear the Army uniform, which will be provided. Prerequisites: Class is open only to contracted students.

Modern Languages Courses

82-101 Elementary French I

Fall and Spring: 12 units

This course is for students with no prior experience in French. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken French, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of French and francophone cultures through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in French must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: None

82-102 Elementary French II

Fall and Spring: 12 units

This course is designed for students who have taken first-semester French at Carnegie Mellon or learned its equivalent as determined by placement. Using a proficiency-oriented approach, students will expand contextually appropriate interpersonal communication skills in both written and spoken French, continue to develop reading and listening skills through the use of various media, review previously learned and practice new grammar and vocabulary, and gain a further understanding of French and francophone cultures through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in French must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: 82-101 or 82-103 or placement. Prerequisites: 82-101 or 82-103

82-103 Elementary French I Online

Fall and Spring: 12 units

This course is designed for students with no prior experience with French and who need a more flexible approach to language learning than that offered in a standard classroom course. Beginning language learners will develop communicative competence in the four basic skills of listening, speaking, reading and writing. Basic vocabulary and sentence structures for use in essential daily-life situations, as well as cultural information, are taught through the course materials and assignments. Materials are web-based, with extensive use of Internet technologies for listening, reading, and communication. During regular semesters, this course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. A student with prior experience in French must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: None

82-104 Elementary French II Online

Fall and Spring: 12 units

This course is designed for students who need a more flexible approach to language learning than that offered in a standard classroom course. Students will learn more useful and complex expressions and sentence structures necessary for use in everyday life. Students will continue building their skills in listening, speaking, reading, and writing for everyday communication. Additionally, course materials and assignments are designed to improve students' understanding of French and francophone cultures and societies. Materials are web-based with extensive use of Internet technologies for listening, reading, and communication. During regular semesters, this course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. A student with prior experience in French must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-101 or 82-103 or placement. Prerequisites: 82-101 or 82-103

82-110 Self-Study in Less Commonly Taught Languages

Intermittent

Students who pursue study of a less-commonly taught language that is not offered by the Department of Modern Languages may receive appropriate credit for their work if they demonstrate successful completion of their study at an approved institution of higher learning. The course may provide the option for individualized language instruction for students working at their own pace in consultation with an instructor using materials identified by the National Association of Self Instructional Language Programs. Courses must emphasize the development of oral-aural skills and introduce basic reading and writing. Students must be prepared to devote regular individual study in addition to the time spent each week in consultation with their instructor. Prerequisite: Permission of the Department Head is needed to take this course

82-111 Elementary Arabic I

Fall: 12 units

This course is for students with no prior experience in Arabic. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken Arabic, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of Arab cultures through class activities. Students will primarily learn Modern Standard Arabic for reading, writing, listening, and speaking, with a minor focus on learning the Egyptian and Levantine dialects for listening and speaking. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). A student with prior experience in Arabic must be placed into the appropriate course by visiting Baker Hall 160. Prerequisite: None

82-112 Elementary Arabic II

Spring: 12 units

This course is designed for students who have taken first-semester Arabic at Carnegie Mellon or its equivalent. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken Arabic, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of Arab cultures through class activities. Students will primarily learn Modern Standard Arabic for reading, writing, listening, and speaking, with a minor focus on learning the Egyptian and Levantine dialects for listening and speaking. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). A student with prior experience in Arabic must be placed into the appropriate course by visiting Baker Hall 160. Prerequisite: 82-111 or placement. Prerequisite: 82-111

82-114 Arabic for Global Exchange Online

Fall and Spring: 6 units

Arabic for Global Exchange is a course in Arabic language and culture that utilizes cognitive learning technologies and computer-assisted language instruction to enhance educational, governmental, and business exchanges that are increasingly vital to public policy and economic development in the global economy. This is a mini-course for individuals with no proficiency or extremely limited knowledge of Arabic language and culture who are about to begin study or work in an Arabic-speaking context. The course introduces learners to basic concepts and information to facilitate entry and engagement in an Arabic-speaking environment. The Arabic for Global Exchange project aims to meet a need for high quality, communication-oriented instructional materials to introduce basic cultural knowledge and survival language. Arabic for Global Exchange is a six-week, six-lesson, half-semester course (equivalent of six weeks of university-level instruction), or roughly sixty hours of student effort. Each of the six lessons in the course includes texts and activities to promote acquisition of cultural content in English as well as basic introductory exposure to the Arabic language. Prerequisite: None

82-115 Beginning Arabic for Oral Communication

Intermittent: 6 units

Beginning Arabic for Oral Communication is designed for students who have either taken Arabic for Global Exchange or desire to learn how to orally communicate in Arabic. This course does not teach how to read or write Arabic. It offers students the opportunity to engage in conversation that expands on the linguistic topics offered in Arabic for Global Exchange, using a spoken Arabic that would be widely understood anywhere in the Arab World. The conversation topics include greetings, explaining one's background, formal and informal meetings, eating out and ordering food, shopping and bargaining, using transportation, expressing feelings and opinions, describing things, people, and hobbies, and in addition, students will learn common expressions and their uses. Prerequisite: None

82-121 Elementary German I

Fall and Spring: 12 units

This course is for students with no prior experience in German. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken German, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of German-speaking cultures through class activities. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). A student with prior experience in German must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: None

82-122 Elementary German II

Fall and Spring: 12 units

This course is designed for students who have taken first-semester French at Carnegie Mellon or learned its equivalent as determined by placement. Using a proficiency-oriented approach, students will expand contextually appropriate interpersonal communication skills in both written and spoken French, continue to develop reading and listening skills through the use of various media, review previously learned and practice new grammar and vocabulary, and gain a further understanding of French and francophone cultures through class activities. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). A student with prior experience in French must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: 82-121 or 82-123 or placement Prerequisites: 82-121 or 82-123

82-123 Directed Language Study: Elementary German I or II

Fall and Spring: 12 units

This course is a directed, instructor-supervised version of the courses 82-121 or 82-122. It is recommended for (1) students who are strongly motivated and have the time, self-discipline, and desire to work independently, (2) students whose schedule precludes enrollment in the regular elementary course, and/or (3) students who have had previous German study but are not prepared to take 82-122. This course develops the fundamental language skills as outlined in the descriptions of 82-121 and 82-122, and students complete the same work as for those courses. Written work is turned in for correction and tests covering each unit of material will be taken according to a schedule determined by the instructor. The instructor will be available during office hours or by appointment for individual consultations and testing. Students are permitted to take only one semester of 82-123. A student with prior experience in German must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: There is no prerequisite for students enrolling for German Elementary I. For students enrolling in German Elementary II, the prerequisite is German Elementary I (82-121) or placement.

82-130 Navigating Chinese Culture: Intro to the Three Kingdoms

Intermittent: 9 units

This course introduces students to the basics of Chinese culture in order to assist them to better understand and appreciate traditional Chinese humanistic ideas, thoughts and value systems, with a focus on the Confucian point of view. Through the study of the classic novel, *The Three Kingdoms*, the most valued virtues within Chinese culture and society - loyalty, filial piety, benevolence and righteousness are presented and discussed. Different aspects of the daily life culture will be introduced as well. Supplementary readings, video clips as well as video games will be used to provide students with a deeper insight, observation and motivation to explore more issues related to Chinese culture, history and philosophy. Assessment will be based on short essays, group projects and individual presentations. Some basic Chinese language instruction will be included to give students a taste of the Chinese language. After taking this course, students will - develop a basic understanding of the essence of Chinese culture - build an awareness of cultural differences between different countries - understand some basic characteristics of Chinese language This course is conducted in English; no prior knowledge of the Chinese culture is required.

82-131 Elementary Chinese I

Fall and Spring: 12 units

This course is for students with no prior experience in Chinese. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken Chinese, develop reading and listening skills through various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of Chinese cultures through class and extracurricular activities. Regular homework, quizzes, tests, and participation in class are mandatory (four in-class hours per week). Students will learn the phonetic transcriptions of Chinese (Pinyin) for speaking and listening as well as Chinese characters for reading and writing. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Chinese must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: None

82-132 Elementary Chinese II

Fall and Spring: 12 units

This course is designed for students who have taken first-semester Chinese at Carnegie Mellon or its equivalent by placement. Students will continue developing contextually appropriate interpersonal communication skills in both written and spoken Chinese, developing reading and listening skills through various media, and working toward a deeper understanding of Chinese culture. Work for this course will include the introduction and use of more complicated sentence structures, grammar, and expressions. Students are also encouraged to communicate in longer sentences and write short paragraphs and essays in Chinese. Regular homework, quizzes, tests, and participation in class are mandatory (four in-class hours per week). Students will continue to learn the phonetic transcriptions of Chinese (Pinyin) for speaking and listening as well as Chinese characters for reading and writing. The elementary level is designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Chinese must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: 82-131 or 82-133 or placement Prerequisite: 82-131

82-133 Elementary Chinese Online I

Fall: 12 units

This course is designed for students who need a more flexible approach to language learning than that offered in a standard classroom course. It is designed to help beginners develop communicative competence in the four basic skills of listening, speaking, reading and writing the Chinese language. Basic vocabulary and sentence structures for use in essential daily-life situations, as well as cultural information, are taught through the course materials and assignments. Materials are web-based with extensive use of Internet technologies for listening, reading, and communication. This course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. Students in this class should be prepared to participate in such studies in the course of their classwork. A student with prior experience in Chinese must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: None

82-134 Elementary Chinese Online II

Spring: 12 units

This course is the continuation of 82-133, Elementary Chinese I Online. Students will continue learning more useful and complex expressions and sentence structures necessary for use in everyday life. Students will also continue building their skills in listening, speaking, reading, and writing for everyday communication, and their understanding of Chinese culture and society. This course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. A student with prior experience in Chinese must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-131 or 82-133 or placement
Prerequisites: 82-131 or 82-133

82-135 Elementary Chinese for Heritage Students

Intermittent: 9 units

This course is designed for students who have some basic knowledge of spoken Chinese, but know little of how to read and write Chinese. While an integrated approach will be applied to the development of all the four language skills of listening, speaking, reading and writing simultaneously, the focus will be on the intensive study of Chinese characters through reading and writing practice. Based on their speaking and listening abilities, students will learn how to communicate in writing in everyday situations. The cultivation of cultural awareness will also be a focus of this course. At the end of this course, students will be well-equipped to continue their study of Chinese at the intermediate level. A student with prior experience in Chinese must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisites: Placement by test and Chinese group advisor

82-137 Chinese Calligraphy: Culture and Skills

Fall and Spring: 9 units

Chinese calligraphy is a crucial part of Chinese culture and world art. It is also a clear manifestation of Chinese philosophy that has influenced Chinese people for several thousand years. This introductory course on Chinese calligraphy provides students with basic knowledge of Chinese calligraphy and how it mirrors Chinese history, culture, and philosophy. It will also introduce the fundamental characteristics of the Chinese writing system, its cultural content, and principles of formation as well as the skills used in Chinese calligraphy. At the end of the course, students will have a good understanding of Chinese characters and their cultural and philosophical background but also be able to appreciate the art and beauty in Chinese calligraphy. Classes include lectures, movies, discussions, hands-on practice, and projects. Field trips and guest speakers may also be arranged if opportunities should arise. Prerequisite: None

82-141 Elementary Spanish I

Fall and Spring: 12 units

Elementary Spanish I is the first part of a two-semester course sequence for beginning students, emphasizing the development of communicative language and cultural competence. Students will work towards improving their writing, reading, listening and speaking abilities in Spanish, such that they become comfortable working with a variety of topics from Spanish-speaking cultural areas. Students will develop basic interactional and routine public communication patterns, frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. This course also provides extracurricular opportunities to interact with members of the Spanish-speaking community. Four hours of in-class instruction per week are required. A student with prior experience in Spanish must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: None

82-142 Elementary Spanish II

Fall and Spring: 12 units

Elementary Spanish II is the second part of a two-semester course sequence for beginning students, emphasizing the development of communicative language and cultural competence. Students will work towards improving their writing, reading, listening and speaking abilities in Spanish, such that they become comfortable working with a variety of topics from Spanish-speaking cultural areas. Students will develop basic interactional and routine public communication patterns, frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. This course also provides extracurricular opportunities to interact with members of the Spanish-speaking community. Four hours of in-class instruction per week are required. A student with prior experience in Spanish must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-141 or 82-143, or placement
Prerequisites: 82-141 or 82-143

82-143 Elementary Spanish I Online

Fall: 12 units

Elementary Spanish Online I is for beginning students, emphasizing the development of communicative language and cultural competence. Students will work towards improving their writing, reading, listening and speaking abilities in Spanish, such that they become comfortable working with a variety of topics from Spanish-speaking cultural areas. Students will develop basic interactional and routine public communication patterns. This course is designed for students with no previous knowledge of Spanish and who need a more flexible approach to language learning than that offered in a standard classroom course. All materials are Web-based, with extensive use of Internet technologies for research, writing, and communication. During regular semesters, this course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. A student with prior experience in Spanish must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: None

82-144 Elementary Spanish II Online

Spring: 12 units

Elementary Spanish Online II is the second part of a two-course sequence, emphasizing the development of communicative language and cultural competence. Students will work towards improving their writing, reading, listening and speaking abilities in Spanish, such that they become comfortable working with a variety of topics from Spanish-speaking cultural areas. Students will develop basic interactional and routine public communication patterns. This course is designed for students who need a more flexible approach to language learning than that offered in a standard classroom course. All materials are Web-based, with extensive use of Internet technologies for research, writing, and communication. During regular semesters, this course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. A student with prior experience in Spanish must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-141 or 82-143 or placement
Prerequisites: 82-141 or 82-143

82-161 Elementary Italian I

Fall: 12 units

This course is for students with no prior experience in Italian. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken Italian, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of Italian culture through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Italian must contact the Department of Modern Languages for placement. Prerequisite: None

82-162 Elementary Italian II

Spring: 12 units

This course is designed for students who have taken first-semester Italian at Carnegie Mellon or learned its equivalent as determined by placement. Using a proficiency-oriented approach, students will expand contextually appropriate interpersonal communication skills in both written and spoken Italian, continue to develop reading and listening skills through the use of various media, review previously learned and practice new grammar and vocabulary, and gain a further understanding of Italian culture through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Italian must contact the Department of Modern Languages for placement. Prerequisite: 82-161 or 82-163 or placement
Prerequisites: 82-161 or 82-163

82-163 Directed Language Study: Elementary Italian I or II

Fall and Spring: 12 units

A self-paced version of first or second semester Elementary Italian, this course is for highly motivated students capable of working independently. The coursework includes weekly classes, aural practice using online materials, periodic assessments, and individual meetings with the instructor. Students are permitted to take only one semester of 82-163. A student with prior experience in Italian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisites: Placement and permission of instructor

82-171 Elementary Japanese I

Fall and Spring: 12 units

This course is the first part of a two-semester course sequence (82-171, 82-172) for students with no prior experience in Japanese. It emphasizes the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Japanese must take the placement exam.

82-172 Elementary Japanese II

Fall and Spring: 12 units

This course is a sequel to Elementary Japanese I (82-171) and continues to further the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Japanese must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: 82-171 or placement. Prerequisite: 82-171

82-173 Introduction to Japanese I

Fall and Spring: 9 units

This course is the first part of a two-semester sequence (82-173, 82-174) for students with no background in Japanese. Since it covers the first half of 82-171 in one semester, it is suitable for those students who need sufficient practice time both in and outside of class to begin their study of Japanese. It emphasizes the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. Regular homework, quizzes, tests, presentations, and class participation are mandatory (three in-class hours per week plus six hours of required homework). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Students who intend to minor or major in Japanese should consult with their Japanese minor or major advisor before deciding on 82-171 or 82-173. Prerequisite: None

82-174 Introduction to Japanese II

Fall and Spring: 9 units

This course is a sequel to Introduction to Japanese I (82-173) for students with no background in Japanese. Since the course covers the second half of the 82-171 in one semester, it is suitable for those students who need lots of practice time both in and outside class. It continues to further the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. The elementary level is also designed to help students learn to reflect upon and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (three in-class hours per week plus six hours of required homework). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Upon completion of this course, students can take 82-172. Prerequisite: 82-173 or placement

82-182 Freshman Seminar: Language and Culture: France's (Dirty) Secrets

Intermittent: 9 units

When someone says France, what do people normally think of? Cheese, wine, and baguettes? Kings and queens? Great literature, painting, and sculpture? Probably not mentioned is the exportation of French Jews at the hands of the Vichy government or the persecution of immigrants in the 20th century. Each nation has its secrets, positive and negative. Theories regarding imagined communities, building national identities, and social constructionism create frameworks with which to explore how the French identity developed for both exportation and internal consumption. Through for example, mass media and historic institutional structures, views of reality are skewed from within a nation, leading to an identity perhaps more imagined than real, fooling everyone about the (dirty) secrets that nations hide. Moreover, these secrets are sometimes hidden even from those belonging to that very nation. Using social constructionism as a theoretical point of departure, students will begin a research project based on one of France's dirty secrets through reading and possibly interviewing French native speakers (in English). No knowledge of French or France is required for this course. All work will be in English, though some work in French outside of class can be requested by individual students. Prerequisite: Freshman status

82-183 Freshman Seminar: Japanese Popular Culture in the 2000s and Beyond

Intermittent: 9 units

This course seeks to expose students to Japanese popular culture (e.g., anime, manga, otaku subculture), acquaint them with various aspects of Japanese culture (e.g. mythology, family culture, technological culture, minority culture, entertainments), and deepen their appreciation of Japanese popular culture mainly in the 2000s (zero nendai, in Japanese) and their understanding of the world-view of the Japanese people in its relation to global trends. Through class discussions and assignments, it enables them to not only recognize but also make connections between what they find in, for example, anime they watch and what they learn from readings about various aspects of Japanese culture. By so doing, it helps them look at Japanese popular culture from the Japanese point of view as well as their own. Through an individual project, it also equips them with the necessary skills for cultural and cross-cultural analyses of Japanese products (e.g., humanoid robots) and practices (e.g., virtual realities as practiced by computer games) that often appear in popular culture. Furthermore it provides them with opportunities to critically examine various factors contributing to the globalization of Japanese popular culture and its impact on the world-view of the Japanese people. Prerequisite: Freshman status

82-186 Freshman Seminar: Introduction to Russian Culture

Spring: 9 units

This course deals with important cultural achievements of the Russian people in different areas. The main focus is on the analysis of relationships between Russian and Western cultural traditions. Class discussions help students to understand and appreciate some of the specific achievements in the development of Russian popular culture. Distinctive aspects of Russian high culture are also highlighted, especially through art and music. The course will include secondary readings, primary documents, and films. The course is taught in English and no previous knowledge of Russian is necessary. Prerequisite: Freshman status

82-187 Freshman Seminar: Money and Morality in Chinese Culture

Intermittent: 9 units

This seminar will introduce students to a variety of approaches to Chinese culture through the prism of cultural attitudes towards money and wealth. What are Chinese ideas about the origins and functions of money? What is an honorable way of making money? Does the government have a responsibility to regulate wealth and fight poverty? How does money interfere in interpersonal relationships? What role does money play in the religious sphere? How are attitudes towards money reflected in everyday language? Is debt a sin? What is a fair price or wage? By looking at specific cases in different phases of Chinese history, from ancient philosophy to contemporary literature and language, students will also be able to gain insights into the various academic disciplines that make up the humanities including philosophy, history, archeology, anthropology, literature, economic history, religious studies, and linguistics. Prerequisite: Freshman status

82-188 Freshman Seminar: The Uses and Abuses of Haiti

Intermittent: 9 units

This first-year seminar on Haiti is intended as an introduction to the field of cultural studies, with Haiti as its subject. For the purposes of this seminar, cultural studies includes history, politics, economics, art (painting, music, literature, film, photography), anthropology, religion, public health, environmental history, and especially language. To understand Haiti today, it is necessary to know the island's troubled and often violent history. An example of the ravages of European colonialism and the Atlantic slave trade, Haiti's struggle for independence illustrates its people's resilience and determination. Through readings, documentaries, and interviews with current Haitians working to improve living conditions, students discover the paradoxes of the current country: a proud, immensely talented people struggling to help each other. Despite being cited as one of the poorest countries in the Western Hemisphere, Haiti is managing to make slow progress despite political corruption, crippling natural disasters and often well-intentioned foreign aid that does little to improve the lives of average Haitians. Subjects covered in the seminar include: Haitian Creole; voodoo ("voodoo"); international relations between Haiti and the United States, France, the Dominican Republic, and other pertinent countries; public health; foreign aid (especially following the January 2010 earthquake), environmental destruction and conservation; and education, particularly for children and young adults. Student work includes reading and reaction papers, film and documentary viewing and analysis, original research on a topic related to Haitian culture, oral presentations at different moments in the course, and a final project that includes research, an oral presentation and a final paper. Prerequisite: Freshman status

82-191 Elementary Russian I

Fall: 12 units

This course is for students who have never studied Russian. It begins the Russian language sequence and is offered in the fall semester only. The course takes a communicative approach to teaching basic skills in listening, speaking, reading and writing. Language is presented in communicative contexts illustrating cultural aspects of daily Russian life. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Daily homework and participation in class are mandatory (four in-class hours per week), as is weekly consultation and conversation practice with a course assistant. A student with prior experience in Russian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: None

82-192 Elementary Russian II

Spring: 12 units

Offered in spring only, this course is designed for students who have taken first-semester Russian at Carnegie Mellon or its equivalent. Students will develop contextually appropriate interpersonal communication skills in both written and spoken Russian, develop reading and listening skills through various media (video, ML server, Internet), understand and begin to control fundamental grammar, acquire vocabulary, and gain a basic understanding of Russian culture. The elementary level is also designed to help students learn to reflect and draw upon strategies employed by good language learners in their second language study. Daily homework and participation in class are mandatory (four in-class hours per week), as is weekly consultation and conversation practice with a peer language assistant. In case of schedule conflict, please contact Professor Castellano at cc62@andrew.cmu.edu. A student with prior experience in Russian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-191 or placement Prerequisite: 82-191

82-198 Research Training: Modern Languages

Fall and Spring

These courses are designed to give eligible and interested students some hands-on research experience working on a faculty project or in a lab in ways that might stimulate and nurture the students' interest in doing more research. They are open to students who are Dietrich College, SHS, or BHA majors, double majors, and minors who will be second semester freshmen or sophomores during the semester they take the course. Fall 2015: Section A Hispanic Comics Section B Using Data to Explore Online Learning Section C: Psycholinguistic: Analyzing Chinese and Korean Speakers Production of English Morphemes Section D: Cross-cultural Currents Between Spain and the Americas: The Case of Chocolate Prerequisites: At least a 3.0 cumulative QPA or approval by petition and permission of instructor A sample course contract can be found here: <http://www.cmu.edu/dietrich/docs/undergraduate/RTC-Contract.pdf>

82-201 Intermediate French I

Fall and Spring: 9 units

At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of French and francophone cultures will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in French must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-102 or 82-104 or placement Prerequisites: 82-104 or 82-102

82-202 Intermediate French II

Fall and Spring: 9 units

At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of French and francophone cultures will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in French must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-201 or placement Prerequisites: 82-203 or 82-201

82-208 Topics in European Studies

Intermittent: 9 units

Summer II, 2015 European Culture Between and After Two Great Wars of the 20th Century How did World War I and World War II change European society and culture? Defining the meaning of ?Europe? or ?European? is complicated, since it refers to both a geographical location and a shared history and cultural identity. Based on interdisciplinary approach to the multiple regions and countries located on a single continent, the course will equip students with the skills, methods, and concepts essential for a better understanding of European culture, society and thought, ranging across tragic events of European history such as World War I and World War II, the rise and fall of Nazi and Communist regimes and ideologies and will focus on the most important cultural developments and achievements of Europe in the 20th and 21st centuries. Students will learn how to present material effectively, to analyze texts critically and to construct coherent arguments.

82-211 Intermediate Arabic I

Fall: 12 units

At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily communication needs. In addition to an ongoing review of basic grammar, a greater variety of expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics related to everyday life. Primary focus will continue to be on Modern Standard Arabic, while continuing to learn the Egyptian and Levantine dialects. In-class and extracurricular activities related to the broad spectrum of Arab culture will be organized to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory (four in-class hours per week). A student with prior experience in Arabic must be placed into the appropriate course by visiting Baker Hall 160. Prerequisite: 82-112 or placement Prerequisite: 82-112

82-212 Intermediate Arabic II

Spring: 12 units

An integrated approach to the study of the Arabic language and culture by means of grammar review, cultural readings and analysis, and intensive practice in written and spoken Modern Standard Arabic, this course is designed to strengthen listening, speaking, reading and writing, within the context of an evolving Arab culture. Through exploration of definitions of culture and analysis of the dynamic role of language in culture and culture in language, the course strives to foster cross-cultural awareness and self-realization while developing proficiency in Arabic. Cultural context and the Egyptian and Levantine dialects are introduced through multimedia materials accompanying the textbook, cultural presentations, social media and apps, and virtual experiences of local Arab-related places and events. A student with prior experience in Arabic must be placed into the appropriate course by visiting Baker Hall 160 Prerequisite: 82-211 or placement Prerequisite: 82-112

82-214 Topics in Modern Arabic Language, Literature, & Culture

Fall and Spring: 9 units

An integrated approach to the study of the Arabic language, literature and culture by means of literary and cultural readings. This course explores definitions of culture and analyzes the dynamic role of language in culture and culture in language, with an aim to foster cross-cultural awareness and self-realization while developing proficiency in Arabic. This course is designed to strengthen listening, speaking, reading and writing, within the context of an evolving Arabic culture.

82-215 Introduction to Modern Arabic Literature and Culture

Fall and Spring

This course is designed to acquaint students with the literature and culture of the Arab world. Through lectures, discussions, and class presentations students will gain knowledge of Arabic fiction and poetry, and examine how these literary productions reflect the cultures, mentalities, and traditions of the Arabs. Students will learn about religion, social structure, government, and the position of women in the Arab world through presentations of these topics in modern Arabic literature. The course will focus on literature written since the beginning of the twentieth century, when the first Arabic novel was published, and will also include a brief survey of older narrative traditions, and how these contributed to modern works. The final course grade will be based on a variable assessment method. Students will select from diverse options for writing, presenting, and creative production. With permission of the instructor, it may be possible to earn 3 additional units of credit for work done in Modern Standard Arabic. Prerequisite: None

82-221 Intermediate German I

Fall and Spring: 9 units

The goal of Intermediate German I is to further develop students' linguistic and cultural knowledge, allowing them to feel more comfortable as a user of German. By the end of the semester, students should be able to: use and understand German in everyday situations; communicate effectively in general areas and in individual areas of interest; understand general cultural perspectives in contemporary Germany; and read and understand authentic materials from German-speaking countries. Activities will help develop the four skills and of cultural knowledge. This course focuses on intercultural concepts and will help students see what things Germans view differently from other nations and what things might be similar. Topics will include issues such as travel, politics, immigration, and music. A student with prior experience in German must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-122 or 82-123 or placement Prerequisites: 82-123 or 82-122

82-222 Intermediate German II

Fall and Spring: 9 units

In this class, students will expand and develop their speaking, listening, reading, and writing skills, as well as their cultural knowledge of German-speaking countries. This course focuses on intercultural concepts and will help students see what things Germans view differently from other nations and what things might be similar. Topics will include issues such as views on German history, prospects for Germany's future, art and artists, and the German film industry. By the end of the course, students should be able to make themselves understood in German and understand German-speakers with experience dealing with foreigners. A student with prior experience in German must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-221 or placement Prerequisite: 82-221

82-227 Germany & the European Union

Spring: 9 units

This course offers an overview of contemporary Germany, its problems and its promise, with a particular focus on German politics, the German economy, and Germany's role in the European Union and in the world system. Primary topics include: 1) Germany on the World Stage; 2) Germany and the Past; 3) the German political system; 4) the German economic system; 5) the European Union, its challenges, and Germany's role in it; 6) Germany, the EU, and multiculturalism and ethnic and cultural pluralism, including the role played in Germany and Europe by ethnic, religious, and cultural minorities. Each of these topics will take about 2-3 weeks of the course. Students in the course will be required 1) to complete all required course readings (the equivalent of about three books in English, although in most cases we will be reading chapters from books rather than entire books, plus about five separate articles in English), 2) to take five short fifteen-minute quizzes on some of the various themes of the course, 3) to do a book review of a book of their choosing dealing with contemporary Germany and/or the European Union and to make a presentation about that book in class, 4) to write three short (four page) papers on the themes of the course, and 5) to participate in two debates about A) Germany's response to the past; and B) Whether or not Germany and the EU should be more open to ethnic, cultural, and religious minorities.

82-230 Topics in Cultural Comparison

Intermittent: 9 units

Courses offered under this repeatable title will transcend the focus on one area or nation or language by engaging in cultural comparison. This course makes full use of the variety of faculty specializations in the department and Dietrich College to broaden students' perspectives and help them gain an understanding of the divergences and convergences of world cultures. This course and all source materials will be in English. Past titles have included The Great Divergence Debate in Chinese Economic History. Prerequisite: None

82-231 Intermediate Chinese I

Fall and Spring: 12 units

This course is the continuation of Elementary Chinese II (82-132). At the intermediate level, students will continue to improve the basic skills of listening, speaking, reading and writing with the goal of becoming more proficient in daily communication needs. In addition to an ongoing review of basic grammar, a greater variety of expressions and complicated sentence structures will be taught so that students can carry on more sophisticated daily conversations on various topics related to every day life. While equal emphasis will still be on both Pinyin and characters, students will be encouraged to use more and more Chinese characters with the help of Pinyin for communication. In-class and extracurricular activities related to the broad spectrum of Chinese culture will be organized to facilitate language learning using knowledge of the cultural background of the language. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory (four in-class hours per week). A student with prior experience in Chinese must take the placement exam. Instructions for the placement exam can be found at Baker Hall 160. Prerequisite: 82-132 or 82-134 or 82-135 or placement Prerequisites: 82-132 or 82-134 or 82-135

82-232 Intermediate Chinese II

Fall and Spring: 12 units

This is the second semester of Intermediate Chinese. Its primary goals are to expand students' vocabulary and knowledge of grammar of the Chinese language by learning more new words, expressions, and sentence patterns needed for everyday communication and by consolidating their knowledge through oral and written practice in and out of class. In this course, students will participate in classroom discussions in Mandarin Chinese on various topics concerning everyday life and write short paragraphs on those topics using Chinese characters. Different aspects of Chinese culture will also be introduced during the whole semester through multimedia, lectures, and discussions. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). A student with prior experience in Chinese must take the placement exam. Instructions for taking the placement exam can be found at Baker Hall 160. Prerequisite: 82-231 or placement Prerequisite: 82-231

82-234 Topics in Chinese History

Intermittent: 9 units

Courses offered under this repeatable title will offer focused surveys of China's history, from the history of the imperial state to the reform period of the last forty years. Through reading original sources in translation and historical scholarship, and engaging in critical discussion, students will gain an understanding of Chinese history and appreciate its meaning for contemporary China. This course and all source materials will be in English. No knowledge of Chinese is required. Past titles have included China in the Age of Reform: 1978-Present, and China and the West. Prerequisite: None

82-235 Intermediate Chinese for Heritage Students

Spring: 12 units

This course is the continuation of Elementary Chinese for Heritage Students (82-135). It is designed to continue using an integrated approach to help students further develop literacy in Chinese. More practice in reading and writing short stories, fables, and other reading passages written with more variety of expressions and complicated sentence structures in Chinese will be the major learning activities in and out of class. Students are also expected to learn the basic components of Chinese characters as well as their origins and cultural implications. Activities related to the broad spectrum of Chinese culture will be organized to facilitate language learning. This course can substitute for 82-232 for the Chinese major and minor. A student with prior experience in Chinese must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisites: 82-135 and permission of instructor
Prerequisite: 82-135

82-237 Topics in Traditional China

Intermittent: 9 units

Courses offered under this repeatable title will explore various aspects of traditional Chinese culture, such as literature and philosophy, the arts, theater and music, traditions of state building, military thought, and the role of women in society, etc. Students will read original sources in translation as well as outstanding works of scholarship that study Chinese traditions from the perspective of diverse academic disciplines. This course and all source materials will be in English. No knowledge of Chinese is required. Past titles have included China's Imperial Traditions. Prerequisite: None

82-238 Topics in Chinese Culture

Intermittent: 9 units

Courses offered under this repeatable title will focus on aspects of modern and contemporary Chinese culture, including, for example, literature, the arts, theater and music, and gender studies. Through the critical analysis of original sources in translation, film, as well as outstanding works of scholarship, students will gain a deeper understanding of important developments in modern and contemporary China and will learn how to locate and evaluate sources of knowledge about China for future study. This course and all source materials will be in English. No knowledge of Chinese is required. Past titles have included Gender & Sexuality in China: Tradition and Transformation. Prerequisite: None

82-241 Intermediate Spanish I

Fall and Spring: 9 units

Intermediate Spanish I is the first part of a two-semester course sequence (82-241, 82-242) designed to familiarize students with the cultures and perspectives of the Spanish-speaking world. Students will develop self-expression across a range of culturally significant topics, improving their speaking, listening, reading, and writing skills while working with longer passages of language in context through reading, writing and listening/viewing (e.g. tv series, movies, short novels, plays) and frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. The course provides extracurricular opportunities to interact with members of the Spanish-speaking community. Prerequisites: 82-142 or 82-144 or placement
Prerequisites: 82-144 or 82-142

82-242 Intermediate Spanish II

Fall and Spring: 9 units

Intermediate Spanish II is the second part of a two-semester course sequence (82-241, 82-242) designed to familiarize students with the cultures and perspectives of the Spanish-speaking world. Students will develop self-expression across a range of culturally significant topics, improving their speaking, listening, reading, and writing skills while working with longer passages of language in context through reading, writing and listening/viewing (e.g. tv series, movies, short novels, plays) and frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. The course provides extracurricular opportunities to interact with members of the Spanish-speaking community. Prerequisites: 82-241 or placement
Prerequisites: 82-241 or 82-243

82-253 Korean Culture Through Film

Intermittent: 9 units

South Korean cinema became one of the most vibrant local film industries at the end of the last century, attracting great attention from both the public and scholars, not only at home but abroad as well. Intriguingly, its renaissance involves a strong tendency to revisit and reassess a variety of historical traumas from the last century, which makes it an important venue for discussing the evolution of modern Korean society and culture. This course thus explores works of acclaimed filmmakers such as Im Kwon-taek, Park Kwang-su, Jang Sun-woo, Hong Sang-soo, Lee Chang-dong, Park Chan-wook, Bong Joon-ho, Kim Ji-woon, etc. to enrich our understanding of social and cultural formations in South Korea over the last century. In examining the voices from the Korean peninsula whose history had remained obscured until recently, this course also aspires to contribute fresh perspectives to broader geopolitical settings such as East Asian and Pacific Rim discourses. Prerequisite: None

82-254 World of Korea, Then and Now

Intermittent: 9 units

Over the past two decades or so, South Korea has grown to become a major player, not only in East Asia, but also in world politics, economy, and culture. While Korean society thus certainly deserves enough attention as a venue for discussing the changes occurring across the world, its history and culture still remains less known than it should be to the outside world including the U.S. This course thus aims to offer an opportunity to explore the evolution of Korean society and culture over the course of its modern history. By enriching the knowledge of Korean history, it also hopes to help the student gain fresh perspectives on broader contexts such as East Asia and the Pacific Rim. This course covers a broad range of time periods: the colonial era to the present. Yet designed to inspire critical approach rather than just offer sketchy overviews, it is structured around key sociocultural issues such as colonial legacies, the cold war paranoia, dictatorship, democratization, national culture, gender politics, diaspora, globalization, hallyu (k-pop/k-drama), etc. To better serve its objectives, this course also utilizes diverse forms of texts: historical studies, critical essays, literary works, films, TV dramas, and music videos. Prerequisite: None

82-261 Intermediate Italian I

Fall: 9 units

This course begins a two-semester course sequence (82-261, 82-262) for intermediate-level students. At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of Italian culture will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in Italian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-162 or 82-163 or placement
Prerequisites: 82-162 or 82-163

82-262 Intermediate Italian II

Spring: 9 units

At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of Italian culture will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in Italian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-261 or placement
Prerequisite: 82-261

82-271 Intermediate Japanese I

Fall: 12 units

This course is the first part of a two-semester course sequence (82-271, 82-272). At the intermediate level, students will continue to improve the basic skills of listening, speaking, reading and writing skills with the goal of becoming more proficient in daily communication needs, and takes an integrated approach to the study of Japanese language and culture, consisting of grammar review, reading, and intensive practice in written and spoken Japanese. Course materials include authentic audiovisual and written texts in addition to the assigned textbooks. Also integrated are cultural explorations through direct interactions with native speakers. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory (four in-class hours per week). A student with prior experience in Japanese must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-172 or placement
Prerequisite: 82-172

82-272 Intermediate Japanese II

Spring: 12 units

This course is a sequel to Intermediate Japanese I (82-271/82-171). At the intermediate level, students will continue to improve the basic skills of listening, speaking, reading and writing skills with the goal of becoming more proficient in daily communication needs, and takes an integrated approach to the study of Japanese language and culture, consisting of grammar review, reading, and intensive practice in written and spoken Japanese. Course materials include authentic audiovisual and written texts in addition to the assigned textbooks. Also integrated are cultural explorations through direct interactions with native speakers. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory (four in-class hours per week). A student with prior experience in Japanese must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-271 or placement
Prerequisite: 82-271

82-273 Introduction to Japanese Language and Culture

Fall and Spring: 9 units

This course is an introduction to modern Japanese. Given the close link between the Japanese language and culture, the examination of the distinctive characteristics of the Japanese language and its sociocultural context provides important insights into contemporary Japan. This course is taught in English and is intended both for individuals who want to gain a better understanding of modern Japanese society, as well as for students of the Japanese language. Prerequisite: None

82-278 Japanese Film and Literature: The Art of Storytelling

Intermittent: 9 units

This course explores how the art of storytelling is in tandem with the vicissitudes of the human condition as illustrated in Japan's variety of fictions, non-fictions, and films in the twentieth and twenty-first centuries. Analyses of each storytelling not only reveal the cultural dynamics behind Japanese modernity, but also invite students to find new insights into Japanese culture and their ways of perceiving our globalized world. What kind of cultural exchanges took place between modern Japan and the West? How are Japan's traditional values transformed in the face of modern technicalization and industrialization, compared to the modernization of other countries? And, in turn, what kind of impact has modern Japanese culture had on today's world? Tackling these questions among others, the course also extends to such issues as the legacy of traditional Japanese culture, the modern Emperor system, World War II experiences, emerging voices of minorities, and popular culture (e.g., anime and subculture). This course is taught in English. Prerequisite: None

82-280 Learning About Language Learning

Fall: 9 units

This seminar focuses on the role of diverse affective, cognitive and social factors in second language learning. All participating students are required to be studying an additional language while taking this seminar. Each class is devoted to discussion of assigned readings as well as to completion of various measures, inventories or questionnaires that assess diverse predictors of second language learning. These data are collected throughout the term, and then analyzed and related to predictions based upon previous research that have been discussed in class. Each student also identifies a "good" or a "poor" second language learner to interview and then report back to the class on the learners' characteristics. Prerequisite: None
Corequisite: Study of a foreign language

82-281 Tutoring for Community Outreach

Intermittent

This course enables students to participate in a community outreach program in the Pittsburgh Public Schools with either elementary school, middle school, or high school students, and, depending on the site, foster their studies of Chinese, French, German, Japanese, Spanish or ESL. The elementary school experience will involve regular visits, mentoring, and tutoring at school sites in the East End of Pittsburgh. The middle school experience provides opportunity for tutoring in Japanese, French, or Spanish at Barack Obama Academy of International Studies. The high school or middle school experience invites advanced students, majors, or minors in Chinese, French, German, Japanese, or Spanish to work with language students and teachers at local schools. During the early weeks of the semester, students will meet to arrange their community outreach activities and prepare for their experience. Depending on the number of units to be earned, students will spend a certain number of hours per week engaged in some of the following activities: attending and participating in the individual and group meetings, working in the schools four to six hours per week, reading and preparing for their volunteer activities, keeping a journal of their experiences and responses to course readings, writing a paper or completing a project at the end of the term that reflects experiences. The final course grade will be based on the student's participation at the school site and fulfillment of the plan set at the beginning of the semester, participation in weekly on-campus discussions, weekly journal submissions, and final synthesis project. Prerequisites: Permission of the faculty liaison plus completion of an information sheet available in the Department of Modern Languages, and clearance forms available through the Leonard Gelfand Center for Service Learning and Outreach.

82-282 Community Service Learning

Intermittent

In this course students of Modern Languages will work in the Pittsburgh community to promote learning of cultures and languages. This work may be done to complement course work in modern languages on campus and involve an experience in one of a variety of community settings, such as a heritage language school, hospital translation center, or neighborhood center. Grade will be based on the student's participation at the outreach site and fulfillment of the plan set at the beginning of the semester. Prerequisite: Permission of instructor

82-283 Language, Diversity, & Cultural Identity

Fall and Spring: 9 units

Culture, language, and identity are intimately tied together. Individuals, families, communities, and nations identify themselves in relation to the language or languages they speak. Local, national, and international governmental organizations make choices about the language or languages they recognize and use for political and economic affairs. The United Nations even recognizes language as integral to maintaining the cultural heritage of communities and peoples around the world, and the freedom to choose one's language of expression as a universal human right. In this course, we will explore a variety of questions, advantages, and challenges related to language diversity and cultural identity across the globe. Our main focus will be on contexts of multilingualism—that is, contexts in which two or more languages may be used. Adopting a comparative case study approach, we will explore the following themes: (i) The historical underpinnings of language diversity and its consequences for cultural identity today (e.g., migration, colonization, conquest); (ii) How language diversity and cultural identity shapes, and is shaped by, local, regional, national, and international politics; (iii) The relationship between language diversity and language use and visibility in public spaces (i.e., the linguistic landscape); (iv) Relations between linguistic communities (e.g., majority and minority language users) and the sense of belonging to a culture. The course is taught in English. Students who wish to take the course as a Modern Languages major or minor elective will need to complete their final project on a topic relevant to the language they study.

82-291 Intermediate Russian I

Fall: 9 units

This course is designed for students who have taken two semesters of Russian at Carnegie Mellon or the equivalent. It is offered in the fall only. This course furthers communicative proficiency through intensive practice in written and spoken Russian. Complex grammatical structures and stylistic variations are mastered and extensive vocabulary is acquired. Through reading materials, fictional and non-fictional, acquaintance is made with the basic components of Russian cultural literacy as well as the distinctive cultural aspects of daily Russian life. Attention is directed toward the dynamic interaction of language and culture in order to foster cross-cultural awareness. Attendance is required at three-hourly class meetings per week, as is weekly consultation and conversation practice with a peer language assistant. In case of schedule conflict, please contact Professor Castellano at cc62@andrew.cmu.edu. A student with prior experience in Russian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-192 or placement
Prerequisite: 82-192

82-292 Intermediate Russian II

Spring: 9 units

This course is designed for students who have taken three semesters of Russian at Carnegie Mellon or the equivalent, and is offered in the spring semester only. The course furthers the study of Russian language and culture through vocabulary expansion and the acquisition of complex grammatical structures and stylistic variations, literary and cultural readings and analysis, and intensive practice in written and spoken Russian in context. Attention is directed toward the dynamic interaction of language and culture in order to foster cross-cultural awareness. Attendance is required at three-hourly class meetings per week, as is weekly consultation and conversation practice with a peer language assistant. One to two hours per day outside of these meetings must be devoted to study and homework assignments. A student with prior experience in Russian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-291 or placement
Prerequisite: 82-291

82-293 Introduction to Russian Culture

Intermittent: 9 units

This repeatable course is designed for both students who know Russian and those who do not and is taught in English; no knowledge of Russian is required. The purpose of the course is to introduce specific developments in the history of Russian culture that account for its distinctive flavor. Past topics include: Russian Fairy Tales; The Russian Avant-garde in Literature, Music and Art; and The History of the Fine Arts in Russia. Attendance at all class meetings and participation in class discussions are required, as are oral presentations and written essays and research papers. Prerequisite: None FALL 2015: Baba Yaga, Koschei the Immortal, the Firebird, Ivan the Tsarevich: Russian fairy tales brim over with monsters and magic, witches and devils, heroes and villains, princes and queens. In this course we examine a wide selection of these tales for what they can reveal about Russian culture's ethics, aesthetics, values and habits of mind. Students discover these through four analytical approaches: structural, psychological, feminist and socio-political. Attention is paid to the ways in which fairy tales hold sway in literature and the fine arts from centuries past right through to the present day. Course requirements include primary and secondary readings, oral presentations, written essays, tests and participation in class discussions. Prerequisite: For students with advanced Russian language skills, 3 additional units can be earned for additional meetings covering reading and writing tasks performed in Russian. Permission of the instructor is required.

82-294 Topics in Russian Language and Culture

Intermittent: 9 units

This repeatable course is designed for both students who know Russian and those who do not and is taught in English; no knowledge of Russian is required. The purpose of the course is to introduce specific developments in the history of Russian culture that account for its distinctive flavor. Past topics include: Russian Fairy Tales; The Russian Avant-garde in Literature, Music and Art; and The History of the Fine Arts in Russia. Attendance at all class meetings and participation in class discussions are required, as are oral presentations and written essays and research papers. Prerequisite: None

82-296 A Century of Russian Film

Intermittent: 9 units

FALL 2014 This course presents a selection of the dominant works, directors and genres that have defined Russian film-making from its birth to the present. About twenty sub-titled films are viewed and discussed within the context of artistic trends and political events shaping the Russian film industry. Films are screened in class on Mondays. While the primary aim is to acquaint you with Russian film in its cultural context, a secondary purpose is to focus your attention on the aesthetics of film form. This will increase your pleasure in viewing any film, Russian or otherwise. Discussion will be organized around topics such as these: intellectual climate and key issues in national life at the time of a film's making; a film's major and minor themes; historical/national/political/social/artistic issues a film raises; how a film affects its viewers? thinking about these themes and issues. The instructor's own experience as a film director will provide further insight into various aspects of film-making and getting a deeper pleasure from viewing film. No knowledge of Russian is required.

82-299 Alternative Break Project (General)

Intermittent

This course provides ML language students and non-ML students enrolled in an Alternative Break student trip project the opportunity to earn credit by engaging in "connected" modes of knowing, by identifying and analyzing a problem, and developing plans for short-term and sustainable solutions, reflecting, and creating and disseminating an informational and interpretive website and print materials about their experience. Students will also bring to bear or gain experience in non-academic skills/talents/interests in areas like photography, image editing, video production, writing, design, website development, sound recording, and art, etc., by doing community service under the auspices of Carnegie Mellon University's Alternative Break program. Students will earn three (3) units for full participation and fulfillment of course requirements. With the approval of the faculty facilitator, an additional three (3) units may be earned by completing an additional assignment. Prerequisite: Permission of instructor

82-300 Topics in Cross-Cultural Studies

Fall and Spring: 9 units

This course is designed for students in different disciplines who desire to develop knowledge about Arab societies, their customs, traditions, history, and current ways of thinking. This course fosters understanding about Arab cultural dynamics and appreciating cultural differences within the Arab World and between Arab and Western societies, with the aim of bridging these differences. Prerequisite: None FALL 2015: Arab Cultural Issues and Active Agency in Modern Arab Society The Arab World comprises many North African and Middle Eastern countries with multiple ethnicities and a long, rich history. This course raises awareness of many Arab cultural issues in light of the historical, economic, social, and political characteristics that distinguish the modern Arab World. The course begins with the East-West discourse and the creation of stereotypes, Saïd's theory on Orientalism, being a "careful reader" of the literature and media that may create such stereotypes, and how to go beyond them so as to gain a true understanding of the hybrid nature of Arab societies. The course will then discuss the key religious and cultural beliefs and customs, and the challenges that construct Arab thought and relations (family- marriage- sexuality). The selected readings will highlight Arab men and women writers' roles as social critics of the sometimes injustices endured under a dominant patriarchal social system. There will also be an appreciation of Arab artistic creativity (photography, painting, calligraphy). The course material will vary between newspapers and critical articles, novels, films, and documentaries. Students will have the opportunity to engage in a video-conference dialogue with students in the American University in Cairo and other students from Arab countries. Grades will be based on attendance and participation, weekly journal entries, a presentation, and a final paper. Class discussion and readings in English.

82-303 Introduction to French Culture

Fall and Spring: 9 units

Through deep cultural analysis of France and the French, students attempt to discover the French "mentality" or what it means to be French. By studying French history, institutions, regions, literature, and current events, students understand how a cultural identity is developed throughout a country's history. Comparisons between current events and France's cultural and social development from the Renaissance forward explain in part the French mentality and how and why France and the French react to the world as they do. The coursework will develop students' skills in writing, reading, speaking, and listening, and improve their control of grammar through class discussions, presentations, and essays. Prerequisite: 82-202 or placement
Prerequisites: 82-202 or 82-204

82-304 The Francophone World

Fall and Spring: 9 units

This course introduces the students of French to several of the francophone regional cultures outside of France, including North and sub-Saharan Africa, Belgium, Switzerland, Quebec, Louisiana, and the French Antilles. The culture commonly associated with the French language is the primarily Christian and Cartesian European tradition. Through this course, students will learn about the socio-political and cultural realities of the Francophone sphere. The course will also explore the multiple synthetic cultural realities which have arisen through the colonial and post-colonial processes of contact between European and non-European cultures, and which are now expressed through the medium of the French language. Students will expand their interpersonal and presentational communication skills in both written and spoken French, improve reading and listening skills through various media so as to analyze content objectively, use appropriate vocabulary and grammar to express critical judgments, synthesize ideas from different source materials, and continue perfecting cultural analysis skills. Assignments will include using accepted academic conventions for research documentation and exposition. Social debates and current events will add a valuable perspective to our study. Prerequisite: 82-303 or permission of French and Francophone Studies advisor
Prerequisite: 82-303

82-305 French in its Social Contexts

Fall and Spring: 9 units

This course examines the social, historical, and political contexts of the French language, with emphasis on how French has changed, and continues to vary, across time and space through such questions as: How did French arise as a language distinct from Latin and other Romance languages? Why did French spread across Europe, North America, Africa, and Asia? What are the similarities and differences between different varieties or dialects of French across the world? How have outside influences and other languages impacted the French language, and how has French influenced other languages? How do language policies affect the form and use of French in different regions of the world? Through readings, videos, homework, class discussions, and hands-on activities, students will gain an understanding of the various subdisciplines of the field of sociolinguistics in general and of French sociolinguistics in particular. A final project includes original research, an oral presentation, and a paper. Prerequisites: 82-303 and 82-304, or permission of French and Francophone Studies advisor
Prerequisites: 82-303 or 82-304

82-311 Arabic Language and Culture I

Fall: 9 units

This course aims to build students' knowledge of the Arab world and at the same time promote the development of their linguistic abilities in Modern Standard Arabic (MSA) through reading, writing, speaking, and listening. A broad range of literary and nonliterary texts and topics relating to the Arab world and Arabic-speaking peoples are studied. Each iteration of this course focuses on a particular theme, such as Current Issues in the Arab World, Ethnic Groups in the Arab world, Arabic Poetry and Proverbs, Education, Economic and Social Development, etc. Students will be asked to write short essays and give brief oral presentations in class. A student with prior experience in Arabic must be placed into the appropriate course by visiting Baker Hall 160. Prerequisite: 82-212 or placement
Prerequisite: 82-212

82-312 Arabic Language and Culture II

Spring: 9 units

This course is a sequel to 82-311 and also aims to build students' knowledge of the Arab world and at the same time promote the development of their linguistic abilities in Modern Standard Arabic (MSA) through reading, writing, speaking and listening. A broad range of literary and nonliterary texts and topics relating to the Arab world and Arabic-speaking peoples are studied. Each iteration of this course focuses on a particular theme, such as Current Issues in the Arab World, Ethnic Groups in the Arab world, Arabic Poetry and Proverbs, and Education, Economic and Social Development. Students will be asked to write longer essays and give more extensive oral presentations than in 82-311. A student with prior experience in Arabic must be placed into the appropriate course by visiting Baker Hall 160. Prerequisite: 82-311 or placement

82-313 Readings in Islamic History

Fall: 9 units

This course focuses on Islamic history and enables students to read authentic historical texts in Arabic written three to five centuries ago and to understand the cultural context that gave rise to these texts. Students also will continue to develop their ability to express their ideas both in speaking and in writing and to develop their listening skills in Modern Standard Arabic. Prerequisite 82-212 or approved equivalent.

82-314 Business Arabic

Intermittent: 9 units

Note: This course is available only on the Qatar campus. The aim of this course is to develop the students' linguistic abilities in Modern Standard Arabic (MSA) for business purposes through reading business articles and documents, writing summaries, reports, memos and e-mails, and giving oral presentations of projects. Developing translation skills from Arabic to English and vice versa is a major component of the course. Prerequisite or approved equivalent.

82-320 Contemporary Society in Germany, Austria and Switzerland

Fall: 9 units

This course offers an introduction to contemporary German culture since 1989. Switzerland and Austria will be frequently included in class discussions but the main focus will be on Germany. In the wake of reunification, constructions of German cultural identity have undergone radical changes. Through encounters with articles, literary texts, popular music, and film students will explore these transformations and examine German culture and (both individual and collective) "identities" after reunification. The class sessions will be organized around several thematic segments, including East/West relations during and after reunification, German media, multiculturalism and minorities, and, finally, a segment on how to navigate the business world in German-speaking countries. The course will be conducted entirely in German and is designed to deepen students' understanding and awareness of issues in contemporary German culture. Prerequisite: 82-222
Prerequisite: 82-222

82-323 Germany, Austria and Switzerland in the 20th Century

Spring: 9 units

This course advances proficiency in communicative and grammatical skills in the German language and knowledge of German-speaking cultures through the study of important events, trends, and people of the twentieth century in Germany, Austria, and Switzerland. Examples will be drawn from literature, newspapers, television, film and other sources. Students will be expected to complete assignments that demonstrate the ability to express critical judgments in both written and oral form, documented through readings and personal research. The course includes a review of the most troublesome points of German grammar. Prerequisite: 82-222
Prerequisite: 82-222

82-327 The Emergence of the German Speaking World

Intermittent: 9 units

The Italian literary theorist Franco Moretti has written that "Germany is a sort of Magic Stage, where the symbolic antagonisms of European culture achieve a metaphysical intractability, and clash irreconcilably. It is the center and catalyst of the integrated historical system we call Europe." This course is a general introduction to German culture, German history, and German society, with a focus on Germany's role as center and catalyst of the European system. The course is conducted entirely in German. Its goal is to provide students with a basic level of cultural literacy about the German-speaking world. In the course, we will study major trends from the earliest days of German civilization through the middle ages but with primary emphasis on the 18th, 19th and 20th centuries and with a special focus on problems of national, political and cultural identity. Students coming out of the course should have a broad understanding of the various tensions and problems that have characterized German culture and society for the last two centuries. In addition to broadening students' cultural knowledge about the German-speaking world, this course will continue to emphasize the improvement of students' ability to speak, read, write, and listen to German. Prerequisite: 82-320 or 82-323
Prerequisites: 82-320 or 82-323 or 82-324

82-331 Advanced Chinese I

Fall and Spring: 9 units

This course is designed for students who have reached the intermediate level of proficiency in the use of Chinese language to develop their language competency in all four skills to a more advanced level. Students will expand explicit knowledge of socio-cultural influences on Chinese language use, and be able to apply the knowledge to conduct culturally appropriate spoken and written communication across various social domains and genres.

Topics to be covered in this class will be closely related to some current social issues in China, such as population, youth, love & marriage, and popular culture. Students will also develop a repertoire of strategies and resources to assist their learning so that they will be gradually become autonomous learners who are able to conduct independent learning of the Chinese language, culture, history, and society. Classroom discussions and essay writing will be the major forms of work throughout the semester. Research projects on Chinese culture and society are also a requirement so that students will be able to gain a deeper understanding of the cultural background of the language. With Pinyin for support, students will learn both the traditional and simplified forms of Chinese characters. Prerequisite: 82-232 or 82-235 or placement
Prerequisites: 82-232 or 82-235

82-332 Advanced Chinese II

Fall and Spring: 9 units

A continuation of Advanced Chinese I, this course is designed to improve students' proficiency to function with Chinese in situations beyond their everyday life. Students will continue to learn more complex language phenomena in order to use exposition, explanation, description, and argumentation in Chinese. More sophisticated language phenomena will be introduced to students together with their social and cultural background through texts and multimedia related to various social issues in China today, for example, traffic, education, employment, healthy living, and other human relations as well as economic situations. Classroom discussion and research project presentations will be the major forms of oral practice, and writing practice will mainly focus on essays and group research project papers. Prerequisite: 82-331 or placement
Prerequisite: 82-331

82-333 Introduction to Chinese Language and Culture

Fall and Spring

This course will introduce students to important developments in China's culture and language since the end of the nineteenth century focusing on the interactions between Chinese and Western cultural traditions and the historical, social, and political contexts in which these interactions evolved. The following questions will motivate discussion: What is Chinese culture in the modern world? What is "modern" and what "traditional" Chinese culture? How does high culture interact with folk culture and popular culture? How have education and language policies shaped Chinese cultural identities over the last century? What does it mean to be Chinese in a diaspora context? Secondary readings, primary documents, and video material chosen for analysis will provide students with important insights into the diverse factors that have been shaping contemporary Chinese culture. This course is conducted in English with no requirement of prior knowledge of Chinese language for students who take it for 9 units. Students who take this course towards fulfillment of requirements for the Chinese major or minor must register for 12 units requiring completion of three (3) units of study in Chinese Studies. Prerequisites: To register for 12 units, there is a prerequisite of either 82-232 or 82-235 or placement. There is no prerequisite for students taking the course for 9 units.

82-334 Structure of Chinese

Fall and Spring: 9 units

This is an upper-level Chinese course for students who have completed the requirements for intermediate Chinese with the goal of enabling students to build up a more comprehensive and systematic understanding of the structure of Chinese so as to lay a solid foundation for the further development of their advanced level language proficiency. This course will cover major complicated structural phenomena in Modern Chinese through the study of specially selected sample texts. Special emphasis will be given to high frequent errors and weaknesses on particularly problematic elements and sentence structures that are common among non-native Chinese speakers. After this course, students can expect to have the ability to use Chinese more accurately and naturally in both speaking and writing on sophisticated topics in life. Prerequisite: 82-232 or 82-235 or placement
Prerequisites: 82-232 or 82-235

82-335 Readings in Chinese

Intermittent: 9 units

This is an upper-level Chinese Reading course for students who have reached intermediate level proficiency in Chinese. It is designed to train students to read extensively in Chinese with fluency and proficiency within a context of rich cultural content. Materials used in this class are selected from traditional fables, mini-stories, and articles from newspapers and magazines on the lifestyle and social changes in modern China. While discussion will be one of the major class activities, students are strongly encouraged to profit from opportunities to build their vocabulary and improve their sense of the Chinese language through reading and writing assignments throughout the semester. Prerequisite: 82-232 or 82-235 or placement
Prerequisite: 82-232

82-337 Mandarin Chinese for Oral Communication I

Fall: 9 units

This course is designed for students who have reached intermediate level in reading and writing Chinese, but have little knowledge of Mandarin Chinese pronunciation, as well as those who aim to further improve their speaking in Chinese. Students will be introduced to Pinyin, the phonetic system of Mandarin Chinese, and work to refine and perfect their speaking skills through special attention to different styles, colloquialisms, and dialectal variations of contemporary spoken Mandarin. Course materials will include authentic Chinese TV programs, documentaries, films, recorded materials, and contemporary literary and non-literary texts. Students will be required to participate in intensive speaking activities, such as interviewing native speakers of Chinese, oral presentations, discussions, debates, and special projects. At the end of the course, students are expected to carry on oral communication with native Mandarin speakers in a clearly participatory fashion on topics related to various social issues in Modern China. Prerequisite: 82-232 or 82-235 or placement
Prerequisite: 82-232

82-338 Mandarin Chinese for Oral Communication II

Spring: 9 units

This is an upper-level course focused on the improvement of students' oral communicative competence and self-expression in Chinese. This course is designed for students who have reached intermediate level in reading and writing Chinese, and who would like to promote their oral communicative competence and knowledge of Chinese culture. It is a seminar-type class that relies on active participation from the students. Students will practice various conversational tasks, such as giving presentations, participating in discussions and debates, interviewing, describing, and interpreting. Topics will include current events and cultural trends in the U.S. and China, analysis of Chinese culture and comparisons with other cultures, contemporary Chinese television shows and movies, and other debatable and interesting issues. Prerequisite: 82-232 or 82-235 or placement
Prerequisites: 82-232 or 82-235

82-339 Business Language & Culture in China I

Fall: 9 units

Designed for students who have had at least two years of Chinese language training, this course enables students to enhance their language proficiency for professional environments and develop an in-depth understanding of the current business culture in China. Substantial authentic materials from newspapers, magazines, TV shows and online sources will be introduced in class to help students interact smoothly with the Chinese business world. Students will also be encouraged to foster creative and independent thinking, which is crucial for survival in today's business world, through a variety of classroom activities such as group discussion/debate, professional interviews, business projects and presentations, and oral/written business reports. Professional language skills (both speaking and writing) as well as social and business etiquette will be introduced and reinforced throughout the course. Sample topics include: China's reform and "opening up", China's market, "Made in China", marketing in China, Chinese business cards and connections, Chinese etiquette at business banquets, consumer psychology in China. Prerequisite: 82-232 or 82-235 or placement
Prerequisites: 82-235 or 82-232

82-340 Business Language & Culture in China II

Spring: 9 units

The goal of this course is to help students improve their language proficiency in professional environments and develop an in-depth understanding of the current business culture in China. Authentic materials from newspapers, magazines, TV shows, and online sources will be introduced in class to help students interact smoothly with the Chinese business world. Students will be encouraged to foster creative and independent thinking skills, which are crucial for survival in today's business world, through a variety of classroom activities such as group discussion/debate, professional interviews, business projects and presentations, and oral/written business reports. Professional language skills (both speaking and writing) as well as social and business etiquette will be introduced and reinforced throughout the course. Sample topics include: appreciation of the Chinese currency RMB, the Chinese perspective of privacy, euphemism in Chinese culture, China's gift-giving culture, how to properly promote yourself in China, the Chinese perspective of wealth management, the Chinese management style. Prerequisite: 82-232 or 82-235 or placement Prerequisites: 82-339 or 82-331

82-342 Spain: Language and Culture

Fall and Spring: 9 units

This course is part of the post-intermediate, 300-level program that forms the introduction to the major or minor in Hispanic Studies. Students may begin with any one of the three courses at this level or they may be taken concurrently. FALL 2015: This course will focus on the cultures of Spain, the autonomous regions, and the creation of a national identity as a reaction to the multiple ethnicities that have inhabited the Iberian Peninsula since ancient times. ¿Qué es España? ¿Cómo es España? ¿Qué escribe España? ¿Qué está haciendo España ahora? To answer these questions, students will undertake the study of important historical moments and issues that have shaped the development of Spain, through literature, language, politics, geography, history, music, art, film and architecture of Spain. Students will explore the diversity of cultures within Spain and their past and present struggles in issues of war, religion, gender, race, class, immigration, social movements among others. In addition to building an understanding of the cultures of Spain, this course advances proficiency in grammatical accuracy and verbal communication. Students are expected to work in groups, participate passionately, give class presentations and communicate fully in Spanish. A short final essay in Spanish is required. Prerequisites: 82-244 or 82-242

82-343 Latin America: Language and Culture

Fall and Spring: 9 units

This course is part of the post-intermediate, 300-level program that forms the introduction to the major or minor in Hispanic Studies. Students may begin with any one of the three courses at this level or they may be taken concurrently. FALL 2015: This course will explore Latin American culture and language, focusing on issues of cultural identity. Tracing the historical thread of the construction of Latin American cultural identity, six periods will be identified as they are organized around crisis when the topic of ¿Who we are? becomes a central debate (Larraín 1996). These periods include: the conquest and colonization, the independence and constitution of nation-states, the interwar period and the depression, the 1970s and the military dictatorships, and the present globalization stage. These phases in the development of a Latin American cultural identity represent the existence of certain dominant discourses and certain controversies that are important in understanding Latin American culture (Larraín 1996). The idea is to explore how Latin America imagines itself and constructs a narrative about its origins and development. Three main questions will be discussed throughout the course: Where does the discussion about Latin America emerge from?, How does Latin America think of itself?, What does Latin America want to be?. These questions will be explored historically through readings of philosophical and political texts that deal with Latin American identity as well as with literary texts, films, and music that represent practices that enact this/ese identity/ies. Prerequisites: 82-242 or 82-244

82-344 U.S. Latinos: Language and Culture

Fall and Spring: 9 units

This course is part of the post-intermediate, 300-level program that forms the introduction to the major or minor in Hispanic Studies. Students may begin with any one of the three courses at this level or they may be taken concurrently. FALL 2015: In this course, we will explore U.S. Latino cultures and identities to gain insight into how these diverse populations have influenced and themselves been affected by mainstream U.S. culture. The course will trace the historical trajectories of these groups, both those dating back centuries, such as Mexican-Americans and certain Caribbean populations, and those with more recent, quickly growing populations, such as Salvadoran and Honduran immigrants, or ¿Central-American Americans?, in an effort to understand how their identities are forged and transformed over time, considering both internal and external perspectives. Students will examine key moments in each group's history, drawing on materials from a variety of disciplines and sources including but not limited to film, literature, oral histories, newspapers articles, as well as theoretical articles that explore questions of identity, to compare and to contrast their diverse experiences. The course will include discussions and debates on the multiple factors that affect U.S. Latino populations, including for example, U.S. immigration policy, political and economic events in Latin America and the U.S. Further, we will consider the interplay of issues such as race, class, gender and sexuality, in the formation of U.S. Latino identities. Ultimately, we seek to question and to understand the complexities of Latinidad in the 21st century U.S. Prerequisites: 82-242 or 82-244

82-345 Introduction to Hispanic Literary and Cultural Studies

Fall and Spring: 9 units

This advanced-level course is required for the Hispanic Studies major or minor, and should be taken prior to the 400-level courses. The course is transatlantic, incorporating the study of the cultures of Latinos in the US, Latin American and Spain. Topics vary from semester to semester, aiming to provide a thorough understanding of Latin American, Spanish and U.S. cultures in connection to issues such as race, gender, socio-economic class. Students will improve their language use (reading, speaking, writing, and listening). Prerequisites: two out of the following three courses, 82-342, 82-342 or 82-344, or permission of instructor FALL 2015: Cities and Spaces in the Spanish-speaking World: Mapping Identities, Self and Other This course focuses on the city in the Spanish-speaking world, using representations of urban landscapes in literature, film and photography as a lens to study identities and cultures. Cities are a principal organizing unit of society, the site of concentrated political and economic power, spaces that have fostered intense creativity; urban centers have functioned as sites of inclusion and exclusion, of opportunity and marginalization. The course will examine cities in Pre-Colombian times, and then consider their importance during Colonial times, as Spain's Empire was considered to be very urban. Students will explore the significance of the city in the formation of national identities from the 19th through the early 20th century, and then move to more contemporary times, which have seen an explosion of urbanization and the transformation of many cities. At present, Latin America is the most urbanized region in the world, with 80% of its population residing in cities, a figure expected to jump to 90% by 2050. While looking broadly across Spain, Latin America and the US, special consideration will be given to Barcelona, Madrid, Mexico City, Buenos Aires, Santiago, New York and Los Angeles. Prerequisites: 82-342 and 82-343

82-358 Literacies Across Language and Culture

Intermittent: 9 units

This course examines differences and similarities in the ways literacy is learned and used in diverse languages and cultures. By clarifying the distinct characteristics of spoken and written communications, the first analysis will highlight what was made possible through the invention of writing, and in so doing, explore the social and cognitive consequences of literacy. Following that analysis, literacy utilization will be examined in a variety of cultural contexts, as well as its collective impacts on the users. Lastly, through systematic comparisons of literacy education, the importance of identifying the social, cognitive, linguistic factors, which shape literacy in particular cultural contexts will be explored. Prerequisite: None

82-361 Italian Language and Culture I

Fall: 9 units

This is a course in Italian culture and language with a streamlined review of grammar. The course deals with the social, political, economic, demographic, and cultural issues of contemporary Italy. At the same time links are drawn between past and present, evidencing the importance of tradition and history in Italian society. A student with prior experience in Italian must be placed into the appropriate course by visiting Baker Hall 160. Prerequisite: 82-262 or placement Prerequisite: 82-262

82-362 Italian Language and Culture II

Spring: 9 units

This is a course in Italian culture and language with a streamlined review of grammar. The course deals with the social, political, economic, demographic, and cultural issues of contemporary Italy. At the same time links are drawn between past and present, evidencing the importance of tradition and history in Italian society. A student with prior experience in Italian must be placed into the appropriate course by visiting Baker Hall 160. Prerequisite: 82-262 or placement
Prerequisite: 82-262

82-371 Advanced Japanese I

Fall: 9 units

This course emphasizes the acquisition of advanced level of communicative language proficiency by immersing students in authentic cultural explorations. The curriculum includes authentic reading texts, multimedia, interviews with native speakers, and viewing and summarizing Japanese films that depict current Japanese society and cultural trends. The course also provides an individualized learning environment throughout the term in improving students' language skills and cultural proficiency. Students may pick a topic of personal interest for their term project thesis. A student with prior experience in Japanese must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: 82-272 or placement
Prerequisite: 82-272

82-372 Advanced Japanese II

Spring: 9 units

This course continues to further improve the acquisition of advanced level communicative language proficiency by immersing students in authentic cultural explorations. The curriculum includes authentic reading texts, multimedia, interviews with native speakers, and viewing and summarizing Japanese films that depict current Japanese society and cultural trends. The course also provides an individualized learning environment throughout the term in improving students' language skills and cultural proficiency. Students may pick a topic of personal interest for their term project thesis. A student with prior experience in Japanese must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: 82-371 or placement
Prerequisite: 82-371

82-373 Structure of the Japanese Language

Fall: 9 units

This course examines the basic Japanese grammar covered in elementary and intermediate Japanese courses by comparison with English and aids students in systematizing their knowledge of Japanese and in deepening their understanding of Japanese culture (i.e., cultural ways of thinking underlying Japanese verbal behaviors). After a brief discussion of the overall typological differences between the two languages and an initial training to analyze them cross-linguistically, it deals with specific areas of grammar that exhibit pervasive structural and semantic differences and serve as exercises for cross-linguistic analysis. On the basis of the discussions and exercises in class, students gather and analyze relevant Japanese data for their project, which facilitates their understanding of the grammar points and cultural ways of thinking in question, and develops their analytical skills. This course is taught in Japanese. A student with prior experience in Japanese must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Corequisite: 82-272
Corequisite: 82-272

82-374 Technical Japanese

Spring: 9 units

This course seeks to (1) introduce students to technical Japanese or Japanese language used in the field of science and technology, (2) acquaint them with current issues in Japan involving science and technology, and (3) deepen their understanding of the science and technology culture of Japan. It draws on various sources of information such as books, newspapers, video clips, and TV news to familiarize students with current issues in Japan related to science and technology. Through understanding those issues, the course enables them to acquire necessary knowledge of technical Japanese and Japanese cultural perspectives on science and technology. It also requires them to work on an individual project to form and express their own thoughts and opinions on a science and technology issue of personal interest. This course is taught in Japanese. A student with prior experience in Japanese must take the placement exam. Instructions for taking the placement exam are available in Baker Hall 160. Prerequisite: 82-272 or placement
Prerequisite: 82-272

82-380 Independent Study in Second Language Acquisition

Spring

An opportunity for students who wish to pursue independent supervised study in second language acquisition (SLA). In conjunction with a faculty member, students will arrange a program of study to explore aspects of SLA. Prerequisite: Permission of the Instructor.

82-383 Second Language Acquisition: Theories and Research

Fall: 9 units

This course provides an introduction to research and theories in Second Language Acquisition (SLA). Processes that underlie the learning and use of second languages are examined from four perspectives: 1) as linguistic knowledge, 2) as a cognitive skill, 3) as a personality-mediated process, and 4) a socio-culturally mediated process. Factors examined include: age-related differences, the influence of the first language, the role played by innate (universal) principles, the role of memory processes, attitudes, motivation, personality and cognitive styles, and formal versus naturalistic learning contexts. Issues that arise from the course readings are investigated through practical experience in applying theoretical knowledge to small-scale empirical research projects. Students are also provided with opportunities to consider the relevance of these issues to their own language learning experiences. Prerequisite: 82-280 is strongly recommended
Prerequisite: 82-280

82-384 Language and Culture: Language in its Social Context

Intermittent: 9 units

The focus of this course is an examination of the dynamic role that language plays in a multitude of social contexts throughout the world. The goal of the course is to develop students' sensitivity to and awareness of the dual role of language both as a reflection of prevailing social attitudes and as a force that serves to perpetuate many social attitudes and roles. This complex relationship between language, society, culture and personal identity will be demonstrated by examining language use in a wide variety of speech communities throughout the world. The course will consider numerous diverse topics, all of which demonstrate implicit cultural differences and attitudes as manifested through language use. Examples of topics to be considered include standard versus vernacular languages; dialects and variation, language attitudes, bilingualism and multiculturalism in the United States and throughout the world; diglossia; language, literacy and education; non-verbal aspects of language use; gender-based differences in language and culture; socio-linguistic variables in the ethnography of speaking; language loss and language maintenance; politics, language planning and language policy and the impact of languages in contact. The course will be taught as a seminar and will involve regular fieldwork activities to bring the themes of the course to life. Prerequisite: None

82-385 Language Across the University

Fall and Spring

Language credit may be attached to any course, independent study, or project unit for which a student receives content-area academic credit. The program is available at the discretion of the responsible content-area faculty, who should be sufficiently skilled in the chosen language to be able to evaluate the technical content of a student's work. The student, content-area faculty and language faculty negotiate a plan for the semester's work, designed to consume approximately three hours per week for three units of academic credit. The course may be repeated on multiple occasions. Prerequisites: Intermediate level language proficiency or above and permission of a content-area faculty member and the Department of Modern Languages

82-388 Understanding Second Language Fluency

Fall: 9 units

This course examines differences and similarities in the way literacy is learned and used in diverse languages and cultures. In the first step of examining the cognitive and social consequences of literacy, students will analyze the major characteristics of spoken and written communications. Following that analysis, students will compare literacy practices in a variety of cultural contexts and explore how literacy utilization alters its collective impacts on the users. Finally, through systematic comparisons of literacy education, students will identify the social, cognitive, linguistic factors directly affecting literacy development in different cultural contexts. Prerequisite: None

82-396 The Faust Legend at Home and Abroad

Intermittent

This course introduces students to the basic outlines of the Faust story, and examines its nineteenth- through twenty-first-century manifestations in a variety of European, Russian and American novels, plays, films and operas. On the assumption that cultures reveal something distinctive about themselves by the particular way in which they adapt the legend, this course aims to discover how and why these Faustian works of art respond and contribute to the social, political and historical context in which they are produced. On what is the persistent appeal of the Faust legend based? To what needs does it speak? How does the history of its own, continual reemergence affect the meanings it communicates? Prerequisites: None for 9 units; an additional 3 units, requiring permission of the instructor, can be earned for work done in Russian.

82-397 Russia's Demons

Intermittent

Demons and devils, ghosts and goblins, witches and werewolves: Russian literature, art and music and are riddled with them. Where have they come from and why have they stayed? Under what conditions has Russian life conjured them, and what has their power been for creating conditions of their own? This course aims to find out by peering into the netherworld of demonic fantasy by the light of Russian social history from the nineteenth century to the current day. The core of the course is comprised of readings drawn from the literature of Pushkin, Lermontov, Gogol, Dostoevsky, Bely, and Bulgakov. Prerequisites: None for 9 units; an additional 3 units, requiring permission of the instructor, can be earned for work done in Russian.

82-399 Special Topics: Russian in Context

Fall and Spring

This course is designed for students who have completed four semesters of Russian at Carnegie Mellon or for those who have equivalent Russian skills as demonstrated via placement exam. The course focuses on further development of the linguistic and stylistic practices of advanced students based on cultural analysis of Russian literature. Focus is on rapid vocabulary expansion as well as correction of high frequency syntax errors that persist beyond the intermediate level. Written compositions and translations, assigned for homework, are required for the development of grammatical accuracy and stylistic appropriateness. All class discussions are conducted in Russian. A student with prior experience in Russian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-292 or placement

82-400 Russian Studies Topics

Fall and Summer: 6 units

(A1) Literary Culture of the 19th Century Russia (6 Units) The purpose of the course is to give students an introduction to the cultural environment of the Imperial Russia through the works of major 19th century Russian writers. We will read and analyze some masterpieces of Russian fiction, including works of Pushkin, Lermontov, Gogol, Turgenev, Dostoevsky, Tolstoy, and Chekhov. Emphasis will be made on how these brilliant classics reflected turbulent history of the 19th century Russia. (A2) Literary Culture of the 20th Century Russia (6 Units) This mini-course focuses on Russian prose and poetry of the early 20th century. Readings will include the "proletarian" writings of Maxim Gorky, "symbolism" of Alexander Blok, "futurism" and "modernism" of Vladimir Mayakovsky as well as works of some other authors. We will discuss such important issues for 20th century Russian Cultural History as the role of intelligentsia in the Russian Revolution, the content and method of Russian decadence, symbolism, and modernism, as well as imprisonment, liberation, and exile that became so important for many writers and poets.

82-404 Francophone Realities

Intermittent: 9 units

This repeatable course explores targeted francophone cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisites: 82-303, 82-304, and 82-305

82-415 Topics in French and Francophone Studies

Fall: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisites: 82-303, 82-304, and 82-305 FALL 2015: From the 1889 Paris Exposition to Charlie Hebdo: Cross-Cultural Encounters in French Society This course will examine several instances of cross-cultural encounters and their influence on French society. As we analyze literature, visual arts, social debates, and current events, we will investigate how contacts with various forms of alterity have informed conceptions of identity and difference in 20th century France. The construction of Frenchness will be analyzed through the ways in which the society reacts to difference. To achieve these goals, the seminar will focus on five key moments in French history: the Paris Exposition Universelle of 1889, the Interwar period, the Second World War and the Jewish Holocaust, the tourism boom of the 1990s, and the current debates on immigration and integration. Readings will include Pierre Loti's *Aziyadé*, Marguerite Duras' *Un Barrage contre le Pacifique*, Annette Muller's *La Petite Fille du Vel d'Hiv'*, and Hergé's *Tintin en Amérique*. The course will also examine the filmic representations of alterity in Abdellatif Kechiche's *Vénus Noire* and Rose Bosche's *La Rafle*. Social debates and current events will add another level of perspective to our study of French society.

Prerequisites: 82-305 and 82-304 and 82-303

82-416 Topics in French and Francophone Studies

Spring: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisites: 82-303, 82-304, and 82-305

Prerequisites: 82-303 and 82-304

82-420 German Classical Literature

Intermittent: 9 units

This course, conducted entirely in German, provides a basic introduction to the literature of Enlightenment, Sturm und Drang, and classicism in Germany during the second half of the eighteenth century and at the beginning of the nineteenth century. Classical literature appeared in Germany at a later date than in the other major European countries. For this reason, German classical literature tends to be more accessible linguistically to contemporary readers than some other classical literatures. The course will begin with the remarkably lucid and relevant work of Lessing, in particular his plays *Emilia Galotti* and *Nathan der Weise*—both programmatic statements of Enlightenment rationality and critical bourgeois consciousness, moving on to the brief but important Sturm und Drang period, exploring Goethe's revolutionary novel *Die Leiden des jungen Werther*, Schiller's radical drama *Die Räuber*, and Lenz's disturbing play *Der Hofmeister*. The focus will be on Sturm und Drang as a uniquely German phenomenon, and on the reasons for its rapid development and quick demise. The exploration of classical literature will culminate with Goethe's *Faust I*, one of the great masterpieces of western literature and probably the most celebrated and influential work in the German literary canon. Students will also devote time to close reading and aesthetic appreciation of some of Goethe's most beautiful poems. An examination of Schiller's letters *Über die ästhetische Erziehung des Menschen* will round out the exploration of German classicism as an idealistic aesthetic movement. Students will be asked to complete five brief writing assignments over the course of the semester, and to take midterm and final examinations. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor

82-421 German Literature of the Nineteenth Century

Intermittent: 9 units

This course focuses particularly on short fiction such as fairy tales. The nineteenth century was the heyday of Romanticism, in which authors told fantastical tales like E. T. A. Hoffmann's "The Nutcracker and the Mouse King," which was subsequently turned into a famous Christmas ballet by the Russian composer Peter Ilyich Tchaikovsky. Germany is particularly famous for its Romantic culture, and in fact tens of thousands of people all over the world get married every year to the music of German Romantic composers like Richard Wagner and Felix Mendelssohn ("Here Comes the Bride" and the Wedding March, respectively). For many, Romanticism achieved its purest expression in Germany. Students will be asked to participate actively in discussions of the reading, to write a series of short papers, to lead classroom discussion on one class day, and to complete a final project of their choice. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor

Prerequisite: 82-325

82-422 German Literature of the Early Twentieth Century

Intermittent: 9 units

From its inception in 1871, The Second German Empire promised to be an industrial, cultural and military powerhouse on the continent of Europe. But when the hand of the Iron Chancellor, Otto von Bismarck, was removed from the helm by Kaiser Wilhelm II in 1890, the "New Germany" charted a course that would lead to a catastrophic conflict with its neighbors to the west (England and France) and to the east (Russia). This course exams works by some of the major authors of this period (Mann, Wedekind, Hauptmann, Rilke, Kafka) as well as modern film adaptations of their works. Readings will also include seminal thinkers such as Nietzsche, Freud, Marx and Einstein. In addition, the course will employ the visual arts through a survey of the German Expressionists. The purpose of this course is to examine a wide variety of "cultural artifacts" against the backdrop of the political, social, and economic currents of the period. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor
Prerequisite: 82-325

82-425 Topics in German Literature and Culture

Fall: 9 units

This repeatable course explores the culture of the German-speaking nations through a thematic or conceptual focus. Students critically analyze authentic documents, for example, historical, biographical, and literary texts, as well as film and works of the visual arts while improving and expanding their language skills. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor
Prerequisites: 82-426 or 82-320 or 82-327 or 82-323

82-426 Topics in German Literature and Culture

Spring: 9 units

This repeatable course explores the culture of the German-speaking nations through a thematic or conceptual focus. Students critically analyze authentic documents, for example, historical, biographical, and literary texts, as well as film and works of the visual arts while improving and expanding their language skills. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor
Prerequisites: 82-323 or 82-325 or 82-324

82-427 Nazi and Resistance Culture

Spring: 9 units

"How could the land of Goethe and Beethoven also have produced Hitler and the Holocaust?" This is a question that has frequently been posed about Germany. Germany has arguably been the dominant country in Western musical development since the sixteenth century; it has also witnessed an extraordinary flowering of literature, philosophy, and the visual arts. This course will explore what happened to German culture from 1933 to 1945. In particular, it will examine the Nazi assault on modern (or "degenerate") art and the artistic response of the German and foreign resistance to Nazi tyranny. Arts explored will include literature, film, music, and the visual arts. We will read from the works of a variety of writers, including Ödön von Horvath, Anna Seghers, Bertolt Brecht, Adolf Hitler, Albert Speer, Hanns Johst, Paul Celan, and Wilfrid Bade. Film will also play a major role in the course, and students will be required to view (outside of class) and discuss six Nazi-era films, including Veit Harlan's infamous anti-Semitic "Jud Süß", Rolf Hansen's Nazi musical romance Die große Liebe, and Charlie Chaplin's The Great Dictator. Students will be required to lead a classroom discussion, to write a major essay, to write a "Protokoll" (no: /235), to complete all required readings, and to participate actively in classroom discussion. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor
Prerequisite: 82-325

82-428 History of German Film

Intermittent: 9 units

This course is a chronological introduction to one of the world's greatest cinema traditions: German cinema. It moves from the silent cinema of the 1910s to the Weimar Republic, when German cinema represented Hollywood's greatest challenger in the international cinema world. It then addresses the cinema of Hitler's so-called "Third Reich," when German cinema dominated European movie theaters, and moves on to the cinema of divided Germany from 1949-1989, when cinema in the socialist east and cinema in the capitalist west developed in very different ways. In the final week of the semester, the course will address German cinema in the post-unification period, which has experienced a revival in popularity and interest. The two historical foci of the semester will be the Weimar Republic, the classic era of German cinema, and the era of the so-called "New German Cinema" of the 1970s and 1980s, when major German directors developed radical new approaches to cinema and critiques of Hollywood. Among the great directors focused on in the course of the semester will be Friedrich Wilhelm Murnau, Fritz Lang, Leni Riefenstahl, Wolfgang Staudte, Werner Herzog, Wim Wenders, and Rainer Werner Fassbinder. No knowledge of the German language is required for this course. Most of the films will be in German with English subtitles. The course will be cross-listed in the departments of Modern Languages, English, and History. Students will be required to attend class, including all film screenings, to actively participate in discussion, to write a term paper on a topic related to German cinema history, and to take two midterm examinations. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor
Prerequisite: 82-324

82-429 German Reading and Translation Workshop: German in Today's World

Intermittent: 9 units

This course will address issues of translation, mostly from German into English, but to a lesser extent also from English into German. It will focus primarily on texts coming from the spheres of current events, politics, economics, and the cultural sphere, but students will also be encouraged to explore and locate texts based on their own interests and concerns. In order to facilitate well-honed translation, it will be necessary to address points of advanced grammar where the structures of the German and English languages feature not only similarities but also differences. The course will thus also constitute a review of issues in German grammar that English speakers may sometimes find particularly challenging. The language of instruction will be primarily German, and students should be comfortable speaking and listening to German. Students will be required to complete a several translation projects, to locate a number of texts from the contemporary German-speaking world that interest them, and to take a midterm and final examination that will focus on translation, issues of advanced grammar, and cultural content. Prerequisites: 82-320, 82-323, and 82-327, or permission of instructor
Prerequisite: 82-324

82-431 China and the West

Intermittent: 9 units

FALL 2012 This course takes a look at the multifaceted relationship between China and the Western world from Marco Polo's time to the present. The focus will be on how people in China and the West imagined each other in different times of history and in what ways some historical events and figures, as well as concepts and cultural practices are interpreted differently from Chinese and Western perspectives. Students are expected to reach a deeper understanding of the complexities of cultural interactions and their implications for the diverse world in which we now live. The students will read a rich collection of scholarly writings, and the class will be conducted primarily in discussion format. The class is conducted in English and Chinese. Students will complete readings in both English and Chinese. Assessment will be based on participation in the discussion, student presentations, and written assignments (including research papers, book reviews, and translations). Prerequisites: 82-332, or instructor's approval.

82-432 Popular Culture in China

Intermittent: 9 units

This class is a general introduction to various aspects of popular culture in twentieth century and contemporary China. Students will gain a critical understanding of common people's perspectives and experiences with China's revolutionary past and its contemporary global economy through fiction, film, music, newspaper and magazine articles, internet discussion forums, and other forms of visual and written materials. The class is conducted in Chinese, supplemented by occasional scholarly writings in English. Prerequisite: 82-332 or placement
Prerequisite: 82-332

82-433 Topics in Contemporary Culture of China

Fall: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-332
Prerequisite: 82-332

82-434 Studies in Chinese Traditions

Intermittent: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-332
Prerequisite: 82-332

82-435 Advanced Readings in Chinese

Intermittent: 9 units

This repeatable Chinese reading course further develops and refine students' Chinese reading and writing skills at the advanced level. Through critical reading, discussion, and analysis of authentic Chinese texts of different styles from classic and modern literature works as well as media materials with rich cultural content, this course will enable students to improve and expand their ability to read and write in Chinese with greater fluency and proficiency. The readings in this course will include, for example, traditional Chinese fables, mini-stories, articles on the lifestyle and social changes in modern China. The primary focus of this course will be on reading based on students' expanding vocabulary and enhanced sense of the Chinese language. Various styles of writing practice will be an important form of assignments throughout the semester to help students improve their reading proficiency. Prerequisite: 82-331/332/335 or permission of instructor
Prerequisite: 82-324

82-436 Introduction to Classical Chinese

Intermittent: 9 units

This course is designed for students who have reached the advanced level of Modern Chinese and would like to promote their knowledge and skills in reading Classical Chinese, a language shaped in the latter half of the first millennium B. C. which still persists as a living medium of expression today. The course aims to introduce students to the basic syntactic patterns of Classical Chinese and the most frequently used Classical Chinese vocabulary. In the course, readings will be representative selections from ancient Chinese texts, chosen for their historical value, beauty, and influence on later writers. With this knowledge and training, students will be sufficiently equipped to read the Chinese Classics and will gain a deeper understanding of the history of Chinese civilization, culture and language. Moreover, knowledge of Classical Chinese will help students read and understand sophisticated modern Chinese texts, which make frequent use of Classical allusions and constructs. Prerequisite: 82-332 or 82-337 or 82-338
Prerequisites: 82-337 or 82-338 or 82-332

82-439 Modern China Through Literature

Intermittent: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills.

82-440 Studies in Chinese Literature & Culture

Fall: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-332 or permission of instructor
FALL 2015: Chinese Folk Performance This is an introductory course on Chinese folk performance traditions. It aims to help students obtain a general understanding of the various Chinese folk performance forms including puppetry, opera, oral storytelling traditions, and temple festival performances. It will also explore the culture of folk performance, dramatic literature, and performing arts, their relationship with Chinese local culture and societies, and their national and global impact. Class activities will include lectures, guest speakers, and discussion, as well as presentation of multimedia examples of folk performances. At the end of the course, students are expected to have a better understanding of the nature and scope of the Chinese folk performance traditions and gain some fundamental training that will enable them to carry on related fieldwork and research.
Prerequisite: 82-332

82-441 Studies in Peninsular Literature and Culture

Intermittent: 9 units

This repeatable course explores the cultures of Spain through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-345 or permission of instructor
FALL 2015 Pícaros en cuerpo y en alma This course will explore the main character of the Picaresque novel: the Pícaros and the Pícaras. It will establish a dialogue between the Pícaro's body and soul and its role in national politics and religious discourse. Students will study the origins of the Picaresque novel in Medieval and Golden Age Spanish Literature. They will also analyze the failed attempts to define the Picaresque as a contained canon of literature, and thus will explore the Pícaro's survival and adaptations throughout literature, time and across the Americas. This class will be structured as seminar and students will be responsible for presenting readings in class. The class will include literary texts, critical theory articles and several films. A final research paper in Spanish is required.
Prerequisite: 82-345

82-442 Analysis of Spoken Spanish

Intermittent: 9 units

This course serves as an introduction to Spanish Linguistics. Its main goal is to provide students with the opportunity to learn the tools of linguistic analysis and to apply them to the study of Spanish. Attention will be given to different levels of analysis in linguistics including phonetics, phonology, morphology, and syntax. Class time will be divided between lecture, problem-solving exercises, and discussion. Students will have the opportunity to write and present a research paper in specific areas of Spanish linguistics according to their interests. Prerequisite: 82-345 or permission of instructor
Prerequisites: 82-343 or 80-280

82-443 Spanish Reading and Translation Workshop

Intermittent: 9 units

This course is of interest to advanced Hispanic Studies majors and minors as well as non-specialists seeking to develop reading and translation skills in Spanish. The course will be conducted as a workshop to allow different populations to participate in the class. There will be an emphasis on both individual and group work, different theoretical models of translation, and literary pieces, journal articles, critical essays, and materials from Internet news services and bulletin boards. For students with advanced Spanish background (majors & minors), the reading and translation workshop will offer an advanced-level grammar and stylistics review, an opportunity to build vocabulary, and an increased exposure to Hispanic language and culture. Prerequisite: Permission of instructor
Prerequisites: 82-345 or 82-342 or 82-343 or 82-344

82-444 The Structure of Spanish

Intermittent: 9 units

This course will provide students with a theoretical framework and analytic tools to investigate how Spanish speakers represent, construct, and transform their social worlds. In particular, the focus is on language as a social practice through which power relations are maintained or challenged. Using a variety of spoken and written texts, the course seeks to analyze to explore the discourse-semantic and lexico-grammatical features that Spanish users deploy to make meanings and negotiate understandings. This analysis will later be interpreted from an interdisciplinary perspective drawing on social theory and history. Prerequisite: 82-345 or permission of instructor
Prerequisite: 82-345

82-445 U.S. Latino Literature

Intermittent: 9 units

This course proposes to problematize socio-political and historico-cultural issues concerning U.S. Latinos and Hispanic immigrants in the United States. This will involve the analysis and application of assimilation, transculturation and bilingualism theory, and rhetorical/translational problematics of the material under examination. Also of interest will be an ongoing class discussion of Latinos/Hispanics in history, the media, entertainment, politics, and education. Students will consider the question of the "borders," geographical, political and societal, that may or do exist between U.S. mainstream society, Latinos and Hispanic immigrants, and strategies employed by hyphenated-Americans for overcoming, subverting or undermining this situation. Materials for the course will include literature, film, essays, and music by and about Latinos and Hispanics in the United States. Prerequisite: 82-345 or permission of instructor
Prerequisite: 82-345

82-448 Topics in Arabic Language, Literature, & Culture

Intermittent: 9 units

This repeatable course explores the Arab world through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-312
Prerequisite: 82-312

82-450 Advanced Research in Hispanic Language & Culture

Fall and Spring: 9 units

This course permits in-depth, 400-level study in the following courses: 82-342 Spain: Language and Culture, 82-343 Latin America: Language and Culture, and 82-344 U.S. Latinos: Language and Culture. Students will meet with the regularly scheduled 300-level class, read additional texts, and produce research assignments as agreed upon by the instructor and student. The focus is on a deeper understanding and individualized research of the course topics. Prerequisite: Permission of instructor

82-451 Studies in Latin American Literature and Culture

Intermittent: 9 units

This repeatable course explores the cultures of Latin America through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-345 or permission of instructor
Prerequisite: 82-345

82-455 Topics in Hispanic Studies

Fall: 9 units

This repeatable course explores Spanish-speaking cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-345 or permission of instructor FALL 2015: Popular Music and Countercultures in Latin America In this course we will explore popular music as it appears in cultural texts (songs, albums, live performances, music videos, short stories, novels, films, documentaries, etc.) in order to understand its role in the constitution of countercultural groups at the local and global levels. In particular, students will observe how countercultural identities (national, social, sexual, racial, economic) are formed, articulated and negotiated through playing, listening and dancing to popular music. The course will focus on the cultural production of the 1960s-1980s Latin America, and on musical genres such as rock, and Afro-Caribbean rhythms (salsa, son, bolero, guaracha, etc.), though an effort will be made to go beyond this focus and establish connections with alternate and/or more recent examples in order to enrich our historical understanding of the topic. Assigned texts for this course will include readings by Julio Cortázar, Rosario Ferré, Jose Agustín, Luis Rafael Sánchez, Andrés Caicedo, and Ana Lydia Vega; films such as La noche de los lápices, and documentaries like Cocolos y rockeros and Buena Vista Social Club. The course also includes a number of musical examples belonging to different regions and time periods.
Prerequisite: 82-345

82-456 Topics in Hispanic Studies

Spring: 9 units

This repeatable course explores Spanish-speaking cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-345 or permission of instructor
Prerequisite: 82-345

82-473 Topics in Japanese Studies

Fall: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, cultural, social, historical, biographical, filmic, artistic, literary, musical, linguistic, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-372 FALL 2015: Samurai, Kamikaze, & Totoro Over the past century, Japanese cultural icons have changed substantially from loyal Samurai warriors to stoic Kamikaze pilots and cuddly anime characters. This course examines what such icons represent in the Japanese mind, as well as how they have been used by forward-looking film directors in making their audiences aware of the emerging social changes and the altering values associated with the changes. By analyzing eight highly influential films in their respective social and historical contexts, students are expected to reconstruct the social messages conveyed by the directors through these icons.
Prerequisite: 82-372

82-474 Topics in Japanese Studies

Spring: 9 units

This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, cultural, social, historical, biographical, filmic, artistic, literary, musical, linguistic, and theoretical perspectives, while improving and expanding their language skills. Prerequisite: 82-372
Prerequisites: 82-372 or 82-373

82-476 Japanese Discourse Analysis

Fall: 9 units

Through practical language activities, interviews, and field projects, students will develop refined Japanese discourse analytical skills. The course provides opportunities for students to acquire a high proficiency of communication skills both in the spoken and the written forms focusing on topics such as formal speech, job interviews, and business writing, while increasing exposure to Japanese culture. Formality, politeness, and gender differences are some of the major topics discussed in this course as well as how speakers' perspectives and attitudes are reflected within language expressions. Prerequisites: 82-273 and 82-372
Prerequisites: 82-273 and 82-372

82-480 Social and Cognitive Aspects of Bilingualism

Intermittent: 9 units

This course introduces students to the nature and extent of bilingualism in individuals and diverse communities in the US and abroad, with an emphasis on the social, historical and political forces that shape the language varieties and abilities of bilinguals. There is also a brief exploration of the psycholinguistic features that characterize bilingual individuals. It also addresses the challenges and opportunities that bilingualism poses for multilingual societies and individuals. Students will develop their knowledge and critical analysis skills of bilingualism through readings, group discussions, field projects and a research paper. Prerequisite: 82-180 or 82-280 or 82-382 or 82-384 or permission of instructor
Prerequisites: 82-384 or 82-382 or 82-280 or 82-180

82-481 Research Methods in Second Language Acquisition

Spring: 9 units

The course introduces students to research methodology as it applies to language learning and language teaching. It provides an examination of different approaches currently used in Second Language Acquisition (SLA) research ranging from experimental studies to survey investigations. The goal is to develop an ability to critically evaluate, design and implement sound SLA research. Prerequisite: None

82-483 Topics in Modern Languages

Intermittent

This course introduces students to research methodology as it applies to language learning and language teaching through an examination of different approaches currently used in Second Language Acquisition (SLA) research ranging from experimental studies to case studies. The goal is to develop an ability to critically evaluate, design and implement sound SLA research. Prerequisite: None

82-484 Language Assessment

Intermittent: 9 units

This course deals with the theoretical and practical study of aspects of language testing. Purposes and types of language tests are examined in relation to theories of language use and language teaching goals. Testing practices and procedures related to language research and language teaching are also discussed. The course also includes the planning, writing, and administration of tests, and basic test analysis. Prerequisite: None

82-485 Topics in Modern Languages, Literatures, and Cultures

Intermittent

This repeatable course promotes inquiry into linguistic, literary, or cultural topics that may focus on a particular language, literary, and cultural area or on comparative, cross-linguistic, or cross-cultural perspectives. Prerequisite: None

82-486 Independent Study in Languages

Intermittent

An opportunity for students who wish to complement their course work at the 400-level and pursue further advanced study. In conjunction with a faculty member, students will arrange a program of study to explore aspects of the target language and culture. Prerequisite: Permission of instructor

82-487 Writing in a Second Language

Intermittent: 9 units

This course will provide students with a comprehensive understanding of second language (L2) writing by surveying fundamental issues and the relations between empirical research, alternative theoretical perspectives, and pedagogical practices in L2 writing. Topics include text, psychological, and social models of L2 writing instruction and learning. Students are expected to carry out a research project on a focused topic of their choosing concerning L2 writing. Prerequisite: 82-383 or 82-783

Prerequisites: 82-383 or 82-783

82-489 Service Learning in the Community

Intermittent

This is a community-based research (CBR) course for advanced students who wish to bridge service and action research. The course provides an experiential component that allows students to use their second language and culture skills while acquiring or honing their research skills. CBR helps bridge the gap between university and community life to facilitate the development of life-long learning habits and humanistic citizenship. ML students and faculty will jointly design and execute ways in which to 'give back' to the community being studied, which will be chosen based upon the language, culture and/or history of a specific community. Students in this course may participate in historical, ethnographic and cultural research; ethnographic fieldwork; problem solving activities around a particular issue the community is facing; discover how to best identify a particular linguistic/cultural community and document, interpret, preserve and disseminate its history and culture. Class activities may include group, pair and independent reading and research; group and pair travel; group, pair and one-on-one interaction with community members; public presentations; photography, filming, scanning; webpage and document design; and different kinds of writing. Prerequisite: Completion of all 300-level coursework, or an approved equivalent, or permission of instructor

82-491 Topics in Twentieth-Century Russian Literature

Intermittent: 9 units

This course is designed for students seeking an in-depth knowledge of the authors whose innovative achievements defined Russian literature of the twentieth century. Their works are analyzed against the background of cultural history. Attention is paid to the uniquely Russian bond between literature and politics, and the effects of this bond on individual biography are traced out. The particular authors studied vary with each course offering. But in all cases, extensive reading and oral presentation of a substantial research project is required. The course is taught in English, and reading is done in translation. Thus, knowledge of Russian is not required, but it is helpful. Prerequisite: None

82-492 The Historical Imagination in Nineteenth-Century Russian Literature

Intermittent

Pushkin, Gogol, Lermontov, Turgenev, Dostoevsky and Tolstoy all ruminated upon their nation's historical destiny. This course aims to describe the role played by imagination in these authors' efforts to wreak from Russia's past a vision of her future. Emphasis is placed upon the figurative operations of language that allow narrative to function as a guidepost to a collective mission and a map of the individual's location within the projected historical scheme. Lecture and discussion formats are combined at each class meeting. Written papers, oral presentations, and participation in discussions are required. Prerequisites: None for 9 units; an additional 3 units, requiring permission of the instructor, can be earned for work done in Russian.

82-495 Topics in Applied Second Language Acquisition

Intermittent: 9 units

This course aims to expose students to current professional practices and common situations related to teaching Chinese as a Foreign Language (CFL). It will provide an overview of CFL research, teaching and learning with demonstrations of CFL pedagogical issues, applications and solutions. It is intended to help students become familiar with specific CFL issues concerning the special characteristics of the Chinese language, including tones, a character-based writing system, and special Chinese grammatical structures. Students will be able to apply course material to their CFL teaching and research, and feel more comfortable and adaptable in their CFL professional careers. SPRING 2016: Teaching Chinese as a Foreign Language This course aims to expose students to current professional practices and common situations related to teaching Chinese as a Foreign Language (CFL). It will provide an overview of CFL research, teaching and learning with demonstrations of CFL pedagogical issues, applications and solutions. It is intended to help students become familiar with specific CFL issues concerning the special characteristics of the Chinese language, including tones, a character-based writing system, and special Chinese grammatical structures. Students will be able to apply course material to their CFL teaching and research, and feel more comfortable and adaptable in their CFL professional careers.

82-499 Alternative Break Projec (Language Specific)

Intermittent

This course provides advanced ML language students and non-ML students enrolled in an Alternative Break student trip project the opportunity to earn credit by engaging in "connected" modes of knowing, by identifying and analyzing a problem, and developing plans for short-term and sustainable solutions, reflecting, and creating and disseminating an informational and interpretive website and print materials about their experience. Students will also bring to bear or gain experience in non-academic skills/talents/interests in areas like photography, image editing, video production, writing, design, website development, sound recording, and art, etc., by doing community service under the auspices of Carnegie Mellon University's Alternative Break program. Students will earn three (3) units for full participation and fulfillment of course requirements. With the approval of the faculty facilitator, an additional three (3) units may be earned by completing an additional assignment.

82-501 Special Topics: French and Francophone Studies

Fall

Restricted to language majors who wish to go beyond the regular course offerings in French and Francophone Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-502 Special Topics: French and Francophone Studies

Spring

Restricted to language majors who wish to go beyond the regular course offerings in French and Francophone Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-505 Undergraduate Internship

Intermittent

Approved upper-class language majors may receive credit in connection with work experience related to language learning and language use outside of the classroom setting. As a rule, this experience takes the form of work involving language use or research related to language study at off-campus sites or in the Department. Work or research must be done using the language of study. For off-campus internships, there must be an on-site supervisor appointed to collaborate with the faculty advisor in the final evaluation of the student's work and progress. The student will be responsible for three written reports evaluating the non-classroom experience with the language of study and several other criteria. Students must obtain prior approval for proposed work. Prerequisites: Permission of target faculty member and the Modern Languages Internship advisor

82-506 Hispanic Studies Internship

Fall and Spring

Pre-approved, advanced Hispanic Studies majors may receive credit in connection with volunteer or paid work experience (usually in Pittsburgh) in which they primarily or significantly use their target language outside the traditional classroom setting. As a rule, this experience takes the form of work involving language use or research at off-campus sites or in the Department. Work or research must be done using the language of study. For off-campus internships, there must be an on-site supervisor available to collaborate with the faculty advisor in the ongoing and final evaluation of the student's work and progress. Students will be required to write and submit reflexive projects, as determined by the faculty advisor, that evaluate the non-classroom experience in the context of the language- and cultural-learning experience and several other criteria that show how the internship connects back to the student's academic or professional education. Prerequisite: Students must be advanced Hispanic Studies majors and obtain prior permission for the proposed work from a Hispanic Studies advisor and/or the Modern Languages internship advisor.

82-521 Special Topics: German Studies

Fall

Restricted to language majors who wish to go beyond the regular course offerings in German Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-522 Special Topics: German Studies

Spring

Restricted to language majors who wish to go beyond the regular course offerings in German Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

Prerequisites: 82-427 or 82-428 or 82-429 or 82-430 or 82-431 or 82-435 or 82-436 or 82-438 or 82-437

82-531 Special Topics in Chinese Studies

Fall

Restricted to language majors who wish to go beyond the regular course offerings in Chinese Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of instructor and a 400-level course FALL 2015 82531 B: Vision of China: Modern Chinese Society and Culture through Documentary Films and New Media (9 units) By way of watching, analyzing and discussing a series of documentary films and new media made with a documentary touch, this course encourages students to develop in-depth knowledge and understanding of modern Chinese society in the closest proximity to its bare 'reality'. The course will use a thematic approach to cover different social and cultural issues that China is facing nowadays, including the harmony/conflicts between human and nature, the rise of the second generation of the nouveau riche, a humanitarian tale from the AIDS village, the influence of pop culture on modern China, the life of the foreigners in Chinese society, and so on. Students are expected to have excellent Chinese listening and speaking skills and very good writing and reading skills, in order to fully grasp the content of this course. To promote intercultural communication, the course also welcomes the participation of native or near-native Chinese learners. Prerequisites: 82-433 or 82-436 or 82-434 or 82-440

82-532 Special Topics: Chinese Studies

Spring

Restricted to language majors who wish to go beyond the regular course offerings in Chinese Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of instructor and a 400-level course

82-541 Special Topics: Hispanic Studies

Fall

Restricted to language majors who wish to go beyond the regular course offerings in Hispanic Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-542 Special Topics: Hispanic Studies

Spring

Restricted to language majors who wish to go beyond the regular course offerings in Hispanic Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-561 Special Topics: Italian Studies

Fall

Restricted to language majors who wish to go beyond the regular course offerings in Italian Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-562 Special Topics: Italian Studies

Spring

Restricted to language majors who wish to go beyond the regular course offerings in Italian Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-571 Special Topics: Japanese Studies

Fall

Restricted to language majors who wish to go beyond the regular course offerings in Japanese Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-572 Special Topics: Japanese Studies

Spring

Restricted to language majors who wish to go beyond the regular course offerings in Japanese Studies involving group or individual study in a subject area approved by the instructor. Prerequisites: Permission of the instructor and a 400-level course

82-580 Senior Seminar in Modern Languages

Spring: 3 units

This mini-seminar for majors in Modern Languages focuses on general issues in second language learning. It provides an integrative and culminating experience for students as they complete their studies. The course includes consideration of language learning and language maintenance, the role of second languages in American life, issues of linguistic and cultural diversity in the United States today and discussions of multiculturalism throughout the world. The goal of the seminar is for students to reflect upon their language learning experience and to discuss the role that a second language plays in their own lives and in American society today. Corequisite: Open only to Modern Languages majors

82-585 Topics in Second Language Acquisition

Intermittent: 9 units

This repeatable course promotes inquiry into issues related to second language acquisition, for example, use of technology in language learning, language variation, code-switching, pragmatics, sociocultural theory. Students will engage in research and project work and employ qualitative and/or quantitative research methodology and analytical and/or empirical methods to illuminate and understand the acquisition, use, and maintenance of second languages. Prerequisite: Permission of instructor

82-591 Modern Languages Honors Thesis

Fall: 9 units

Modern Languages majors with outstanding academic records and intellectual promise will be given the opportunity to undertake original research under the direction of an individual faculty member. Students and faculty select the research topics. Prerequisites: Senior standing; a 3.5 QPA in one's language major; a 3.25 QPA overall; permission of the Department Head and approved entry into the College's Honors Program

82-592 Modern Languages Honors Thesis

Spring: 9 units

Modern Languages majors with outstanding academic records and intellectual promise will be given the opportunity to undertake original research under the direction of an individual faculty member. Students and faculty select the research topics. Prerequisites: Senior standing; a 3.5 QPA in one's language major; a 3.25 QPA overall; permission of the Department Head and approved entry into the College's Honors Program

82-599 Russian Studies Thesis

Intermittent

The Russian Studies thesis, as described for the Russian Studies major, is required of all Russian Studies majors and consists of researching and writing a thesis employing both Russian-language and English-language sources, and generally completed during the senior year. Work is done individually under the guidance of a Russian Studies advisor. Prerequisite: Permission of instructor

Music Courses

57-008 Vocal Master Class I

Fall and Spring

This is a group coaching class for freshmen voice majors.

57-009 Vocal Master Class II

Fall and Spring

This is a group coaching class for sophomore voice majors.

57-010 Voice Studio Performance Class

Fall and Spring

TBA

57-015 Violin Studio Performance Class

Fall and Spring

TBA

57-016 Viola Studio Performance Class

Fall and Spring

TBA

57-018 Double Bass Studio Performance Class

Fall and Spring

TBA

57-020 Flute Studio Performance Class

Fall and Spring

TBA

57-021 Oboe Studio Performance Class

Fall and Spring

TBA

57-022 Clarinet Studio Performance Class

Fall and Spring

TBA

57-023 Bassoon Studio Performance Class

Fall and Spring

TBA

57-030 Percussion Studio Performance Class

Fall and Spring

TBA

57-100 Convocation

Fall and Spring: 1 unit

A weekly meeting for all music students that features lectures, concerts, and other presentations related to professional development.

57-101 Introduction to Music Technology

Fall and Spring: 6 units

This course gives an overview of music technology through practical information and several hands-on projects. Concepts such as MIDI and digital audio are introduced and specific topics are covered in detail including sequencing, music notation, digital recording, mixing, and production. Throughout the course, students are required to complete several projects and create musical compositions in styles of their own choosing. The student is not graded on the "musicality" of these compositions, but instead on how well they meet the stated project goals by correctly using specific equipment and/or computer programs.

57-102 Finale

Spring: 6 units

This course provides hands-on and in-depth instruction of the Finale music notation program by Coda Music Software. Students will learn how to efficiently use the various notation tools that Finale has to input, edit, and manipulate music. MIDI input, playback, and transcription will also be covered to allow students to quickly notate and hear their music. The goal is to create professional-looking printed scores and parts in a variety of styles from Classical to Contemporary. Open to music majors only except by instructor permission. Introduction to Music Technology (57801/871) or equivalent experience required.
Prerequisites: 57-101 or 57-171

57-103 Elective Studio (Beginning Piano Class)

Fall and Spring: 3 units

TBA

57-109 Elective Studio (Guitar Class)

Fall and Spring: 3 units

Using classical and jazz guitar methods, this course is designed to provide a basic set of techniques that will allow students to pursue the avenue of guitar playing that most interests them. While emphasis will be on developing skills in playing the guitar, a basic understanding of the principles of music theory as applied to the guitar will also be acquired. While few students will find it possible to master all of the materials presented, an exposure to the many possibilities of musical expression available on the guitar and an understanding of basic music theory will help to broaden the students' perspective and make future musical experiences, such as listening and performing, more rewarding. Each student is expected to have his/her own instrument. A guitar in good working condition is essential. An acoustic classical or steel string is preferred, an electric with a small battery operated amp is acceptable. Students having no previous training on the guitar will find this class most valuable.

57-110 Elective Studio (Voice Class)

Fall and Spring: 3 units

Students enrolled in group voice will gain an understanding of basic vocal technique and a variety of singing styles. Students will learn about proper breathing, tone production and posture. Vocal styles will include pop, jazz, musical theater and classical. Students will also explore harmonization, improvisation and audition techniques for the singer. This class is geared towards the beginning student.

57-111 Movement and Dance I

Fall: 3 units

The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.

57-112 Movement and Dance II

Spring: 3 units

The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.
Prerequisite: 57-111

57-149 Basic Harmony I

Fall: 9 units

This course deals with common-practice harmony. It includes triads and their inversions, tonality and modality, non-harmonic tones, cadences, and the basic concepts of modulation. It includes work on fundamentals for inexperienced students.

57-150 Basic Harmony II

Fall: 9 units

This course deals with common-practice harmony. It includes triads and their inversions, tonality and modality, non-harmonic tones, cadences, and the basic concepts of modulation. It includes work on fundamentals for inexperienced students.

Prerequisite: 57-149

57-151 Counterpoint in Theory and Application

Fall: 6 units

In Counterpoint in Theory and Application, students begin by learning the traditional five species of counterpoint in a tonal context. They then build on this foundation, learning to analyze music in terms of the underlying counterpoint and to apply this analysis to performance, and producing original tonal compositions in two voices.

Prerequisites: 57-150 or 57-153

57-152 Harmony I

Fall: 9 units

This course deals with common-practice harmony. It includes triads and their inversions, tonality and modality, non-harmonic tones, cadences, and the basic concepts of modulation.

57-153 Harmony II

Spring: 9 units

This course is a continuation of the study of common practice harmony, exploring dissonant and chromatic harmony.

Prerequisite: 57-152

57-161 Eurhythmics I

Fall: 3 units

Dalcroze Eurhythmics is a unique approach to music learning based on the recognition that meaningful rhythmic movement experience, associated with ear-training and improvisation, reinforces understanding of music concepts, enhances musicianship, and focuses awareness on the physical demands of artistic performance. All concepts are experienced in a musical context. Rhythm reading, notation, analysis, and improvisation are integral to the course. Eurhythmics I covers basic binary and ternary metric units and rhythm patterns in relation to these metric units within simple and compound meters.

57-162 Eurhythmics II

Spring: 3 units

Eurhythmics II introduces combinations of binary and ternary metric units, mixed meters, changing meters, and notation and performance of cross-rhythms.

Prerequisite: 57-161

57-163 Eurhythmics III

Fall: 3 units

Eurhythmics is a unique approach to music learning developed by the Swiss composer and educator Emile Jaques-Dalcroze (1865-1950). Dalcroze discovered that meaningful rhythmic movement experiences away from their instrument allows students to focus awareness on the physical demands of artistic performance while demonstrating knowledge and understanding of the expressive/interpretive as well as the theoretical aspects of music. Sight reading, conducting, notation, analysis and improvisation are integral to the course. Eurhythmics III Course Content: Divisive vs Additive rhythm, Metric transformation, Irregular subdivisions of metric units, Cross rhythms of 3 against 4, 3 against 5, 4 against 5.

Prerequisite: 57-162

57-164 Eurhythmics IV

Spring: 3 units

Eurhythmics is a unique approach to music learning developed by the Swiss composer and educator Emile Jaques-Dalcroze (1865-1950). It is a process for awakening, developing and refining innate musicality through rhythmic movement, ear training and improvisation. Through rhythmic movement, students demonstrate knowledge and understanding of the expressive/interpretive as well as the metrical/structural aspects of music. Sight reading, conducting, notation, analysis and improvisation are integral to the course. Eurhythmics IV Course Content: More complex rhythmic problems encountered in composed music, Changing meters and changing metric units within a composition, Rhythm reading of patterns using small note values, Messiaen rhythm techniques.

Prerequisite: 57-163

57-171 Introduction to Music Technology (self-paced)

Fall and Spring: 6 units

This course gives an overview of music technology through practical information and several hands-on projects. Concepts such as MIDI and digital audio are introduced and specific topics are covered in detail including sequencing, music notation, digital recording, mixing, and production. Throughout the course, students are required to complete several projects and create musical compositions in styles of their own choosing. The student is not graded on the "musicality" of these compositions, but instead on how well they meet the stated project goals by correctly using specific equipment and/or computer programs. This is a self-paced version of 57-101. Material will be covered during weekly class sessions, though students are expected to make time in the evenings or weekends to work on their projects in either the MTC (MM119A) or some other cluster. Students with prior experience may pass out of certain classes and projects by providing teacher with equivalent work (pending teacher approval). In addition to the required projects, there is a final exam which is administered during the last class session.

57-173 Survey of Western Music History

Fall: 9 units

This course surveys the development and contexts of European art music and its global adaptation. While keeping in view the chronology from Gregorian chant to the present, this survey emphasizes key personalities and issues, particularly issues relating to period style and interpretive decisions in performance.

Corequisite: 57-188

57-180 Basic Solfege I

Fall: 3 units

This course improves the student's ability to analyze music aurally and to sing at sight in traditional meters and tonalities using the "fixed do" system. Solfege is the integration of the three cognitive skills: reading music, hearing music, and writing what one hears. Section assignment is determined by a placement test given at the time of the audition or prior to the start of classes. It includes work on fundamentals for inexperienced students.

57-181 Solfege I

Fall: 3 units

This course improves the student's ability to analyze music aurally and to sing at sight in traditional meters and tonalities using the "fixed do" system. Solfege is the integration of the three cognitive skills: reading music, hearing music, and writing what one hears. Section assignment is determined by a placement test given at the time of the audition or prior to the start of classes.

57-182 Solfege II

Spring: 3 units

Continues 57-181 Solfege I.

Prerequisites: 57-180 or 57-181

57-183 Solfege III

Fall: 3 units

Continues 57-182 Solfege II. Students are given assignments of classical music written in the treble, bass, soprano, alto, and tenor clefs. Writing consists of two-part contrapuntal dictations.

Prerequisite: 57-182

57-184 Solfege IV

Spring: 3 units

Continues 57-183 Solfege III. Students learn to read atonal music and practice three-part contrapuntal dictations as well as harmonic dictations.

Prerequisite: 57-183

57-185 Advanced Solfege I

Fall: 3 units

This course improves the student's ability to analyze music aurally and to sing at sight in traditional meters and tonalities using the "fixed do" system. Solfege is the integration of the three cognitive skills: reading music, hearing music, and writing what one hears. Section assignment is determined by a placement test given at the time of the audition or prior to the start of classes. It includes advanced work for experienced students and those with perfect pitch.

57-186 Advanced Solfege II

Spring: 3 units

Continues 57-185 Advanced Solfege I.

Prerequisite: 57-185

57-188 Repertoire and Listening for Musicians

Fall: 1 unit

This course is the required co-requisite listening component for Survey of Western Music History (57-173). In this course, students listen critically to essential music which has stood the test of time and to superior performances. It features 2-3 hours of listening per week.

Corequisite: 57-173

57-189 Introduction to Repertoire and Listening for Musicians

Fall: 3 units

One of the most important ways of achieving musical excellence is to listen. In this course, students listen critically to essential music which has stood the test of time and to superior performances. This on-line course features listening and discussion in a virtual coffee shop atmosphere. 2-3 hours of listening per week. Midterm and final listening tests. Proficiency requirement for freshman music majors.

57-190 Repertoire and Listening for Musicians I

Spring: 3 units

One of the most important ways of achieving musical excellence is to listen. In this course, students listen critically to essential music which has stood the test of time and to superior performances. This on-line course features listening and discussion in a virtual coffee shop atmosphere. 2-3 hours of listening per week. This semester introduces full scores for chamber and orchestral music. Midterm and final listening tests. This course contains midterm and final listening tests. Proficiency requirement for freshman music majors. Other students admitted with instructor's permission.

57-191 Keyboard Studies

Fall and Spring: 3 units

All undergraduate music students are required to take four semesters of keyboard studies during their freshman and sophomore years. The emphasis of this course is to develop a practical keyboard facility, which includes keyboard theory and technique, sightreading, solo and ensemble repertoire, transposition, and a variety of creative activities such as harmonization and improvisation.

57-193 Collaborative Piano Skills I

Fall: 3 units

A required course for first year piano majors. The skills include sightreading, basic keyboard harmony, transposition, and improvised accompaniments for popular or musical theater songs from either a piano reduction or a lead sheet. The students participate in collaborative situations such as juries, recitals, and class presentations. The presentations are critiqued by the instructor and by other students.

57-194 Collaborative Piano Skills II

Spring: 3 units

Continues 57-193 Skills of Accompanying I.
Prerequisite: 57-193

57-207 Secondary Studio

Fall

Provides the opportunity for students to pursue study in a secondary instrument or area. By special permission only.

57-208 Secondary Studio

Spring

Provides the opportunity for students to pursue study in a secondary instrument or area. By special permission only.

57-209 The Beatles

Intermittent: 9 units

This course will focus on the phenomenon of the Beatles. Their songs will be studied, with analysis of the musical and lyrical content and structural elements. What musical styles do the songs address? What were their musical influences? In what ways did their music change over the years? Also, the music's social context will be studied. Why were the Beatles so popular and influential? What exactly caused Beatlemania? How did the group form, grow, and end? The Beatles are the most famous rock group in history; the reasons for this are as much cultural as musical, and we'll study the two elements simultaneously. Open to all undergraduate students.

57-211 Movement and Dance III

Fall: 3 units

The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.
Prerequisite: 57-112

57-212 Movement and Dance IV

Spring: 3 units

The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.
Prerequisite: 57-211

57-220 English Diction

Fall: 3 units

This one semester course helps singers sing English songs from the Classical and Musical Theater repertoire with clarity, accuracy, ease, uniformity, and expressiveness; to illuminate meaning; and to improve tonal quality through diction.

57-221 Italian Diction

Fall: 3 units

A study of the fundamentals of Italian diction and development of legato vocal style through the analysis of grammatical usage, word construction, vowel colorization, and consonant articulation. Included are in-class performance evaluations, listening assignments, critiques, and private coachings.

57-222 French Diction

Fall: 3 units

This course is designed primarily for singers specializing in French Art Songs of the 19th and 20th centuries. It deals with the use of the International Phonetic Alphabet, its application to singing in French, the use of the liaison and the preparation of the text of a song or aria. One-third of the course is theory and two-thirds of the course is spent on application by performance with piano accompaniment.

57-223 German Diction

Fall: 3 units

In-depth study of German diction - development of legato vocal style in German through the analysis of grammatical usage, word construction, vowel colorization and consonant articulation. Included are in-class German diction evaluations, peer assessment, and emphasis on competency in using the International Phonetic Alphabet.

57-227 Jazz Orchestra

Fall and Spring: 3 units

These are Jazz Ensembles (Section A and Section B) which incorporate a comprehensive approach to Big Band performance and study. The music performed is drawn from all eras of big band repertoire with occasional programs of specific composers and genres. The Jazz Ensembles are carefully coordinated with the Jazz Performance Minor program, the Jazz Vocal Ensemble, and other major ensembles in order to challenge and prepare students for professional music career opportunities. Both ensembles perform on the regular School of Music concert series (2-3 shows per semester) and for on-campus events. Trips to festivals and performances at local venues as part of jazz concert series also occur. The "final exam" for this course is a performance at a local jazz club. Admission of undergraduate and graduate students is by competitive audition and placement is by the director. Grading is based on attendance, preparation, and consistent progress.

57-228 Chamber Music: Woodwind and Mixed

Fall: 3 units

Provides an opportunity for students to play in small ensembles, advised by faculty coaches. The performers will develop effective rehearsal techniques, explore chamber music repertoire, deal with issues of intonation and balance, and arrive at interpretive conclusions that are stylistically sound, yet individualistic and creative. A performance is required each semester.

57-229 Chamber Music

Fall and Spring: 3 units

Provides an opportunity for students to play in small ensembles, advised by faculty coaches. The performers will develop effective rehearsal techniques, explore chamber music repertoire, deal with issues of intonation and balance, and arrive at interpretive conclusions that are stylistically sound, yet individualistic and creative. A performance is required each semester.

57-230 Baroque Ensemble

Fall and Spring: 3 units

Carnegie Mellon Baroque is a performing ensemble of 15-25 players consisting of winds, strings and keyboard. Students in this ensemble explore the orchestral and chamber music of the 18th Century. The Ensemble performs on modern instruments, incorporating performance practice ideals of the Baroque era. Throughout the rehearsal process, students are encouraged to study original source materials and arrive at historically informed and musically satisfying performances.

57-231 Chamber Ensemble

Intermittent: 3 units

Provides an opportunity for students to play in small ensembles, advised by faculty coaches. The performers will develop effective rehearsal techniques, explore chamber music repertoire, deal with issues of intonation and balance, and arrive at interpretive conclusions that are stylistically sound, yet individualistic and creative. A performance is required each semester.

Low Brass Ensemble: The low brass ensemble pushes the boundaries of what is "supposed" to be played by an ensemble of this type. Players will be involved in the programming, arranging and planning of performances and will learn valuable musical, creative, promotional and organizational skills.

57-232 Chamber Music: Guitar

Fall and Spring: 3 units

Provides an opportunity for students to play in small ensembles, advised by faculty coaches. The performers will develop effective rehearsal techniques, explore chamber music repertoire, deal with issues of intonation and balance, and arrive at interpretive conclusions that are stylistically sound, yet individualistic and creative.

57-233 Sonatas

Fall and Spring: 3 units

This course focuses on coaching of performance groups with two members. It parallels Chamber Music, which focuses on coaching of performance groups with three or more members.

57-234 Performance for Composers

Fall: 3 units

This course is for composition majors who choose to fulfill the performance elective requirement in the junior year by completing an independent performance project in the fall semester. Examples of projects can include producing a recital of his/her compositions, or pursuing other performing interests, such as writing music for a School of Drama production. Registration by composition faculty permission only.

57-236 Performance for Composers

Spring: 3 units

This course is for composition majors who choose to fulfill the performance elective requirement in the junior year by completing an independent performance project in the spring semester. Examples of projects can include producing a recital of his/her compositions, or pursuing other performing interests, such as writing music for a School of Drama production. Registration by composition faculty permission only. Prerequisite: 57-234

57-240 Acting I

Fall: 6 units

The basics of acting will be established throughout the first year following the guideposts described in Audition, by Michael Shurtleff. Structured improvisations, monologues, scene work, songs, and arias will provide a platform for the development of stage presence and effective communication. Each semester will finish with a group project that provides an opportunity for the students to begin to work together as a cast.

57-241 Acting II

Spring: 6 units

Continues 57-240 Acting I.

Prerequisite: 57-240

57-257 Orchestration I

Fall: 6 units

This is an introductory course for all music majors and required for sophomore composition majors. The characteristics of each instrument of the orchestra are studied thoroughly. Orchestral textures from the classics to contemporary music are studied and analyzed.

Prerequisites: 57-150 or 57-156 or 57-153

57-258 20th-21st Century Techniques

Spring: 6 units

This course is open to all music majors and required for sophomore composition majors. The most important techniques from Debussy to the present will be reviewed in terms of melody, harmony, and form. Tonality, serialism, and aleatoric devices will be studied. Compositional techniques of the 20th Century are put into perspective and compared with other developments in the arts. The class is conducted as an open forum in which discussions are encouraged.

Prerequisite: 57-151

57-271 Orchestration II

Fall: 6 units

Students will analyze music from the Classical to Avant-Garde and use the knowledge acquired to orchestrate piano scores in the appropriate style. Style, practicality, color, and imagination are encouraged. This course is designed for junior composition majors. Other students may register with instructor permission after an interview.

Prerequisites: 57-257 and 57-521

57-273 Piano Pedagogy I

Fall: 6 units

This course offers an historical overview of piano pedagogy including its significant developments over the past forty years. Topics covered include beginning piano techniques, the sequencing of concepts and materials, common problems among beginning pianists, practicing, motivation, and parental involvement. Current representative beginning piano methods will be surveyed.

57-274 Piano Pedagogy II

Spring: 6 units

Beyond the beginning years: this course covers piano pedagogy of intermediate and early advanced level students. Topics include "What is a good piece?" Standard literature and technical development repertoire lists will be studied. The business of piano teaching and the instruction of college keyboard skills for non-piano majors will be discussed.

Prerequisite: 57-273

57-275 Piano Pedagogy III

Fall: 6 units

Continuation of 57-274. Intermediate literature, analysis, teaching, and performance will be covered. Topics include "What is style?"

Prerequisite: 57-274

57-276 Piano Pedagogy IV

Spring: 6 units

Continuation of 57-275. Early advanced literature, analysis, teaching, and performance will be covered.

Prerequisite: 57-275

57-283 Music History I

Fall: 9 units

This course will be a historic overview of each period of Western European art music and in-depth analysis of representative musical genres and forms. The first semester will begin with the birth of Opera and the Baroque era and continue through the early works of Beethoven. We will then analyze the genres/forms of the Middle Ages and Renaissance.
Corequisite: 57-190

57-284 Music History II

Spring: 9 units

This course will be a historic overview of each period of Western European art music and in-depth analysis of representative musical genres and forms. The second semester will begin with the middle period works of Beethoven and will continue chronologically through the major composers, styles, and forms of the 19th and 20th centuries.
Prerequisite: 57-283
Corequisite: 57-289

57-285 Music History III

Spring: 9 units

Missing Course Description - please contact the teaching department.
Corequisite: 57-290

57-289 Repertoire and Listening for Musicians II

Fall: 3 units

This is a continuation of the School of Music's four-semester listening curriculum. Students listen critically to essential music which has stood the test of time and to superior performances. This semester's repertoire includes units focusing on contrapuntal masterpieces from the Middle Ages through 20th Century, and further builds score-reading experience. This on-line course features listening and discussion in a virtual coffee shop atmosphere. 2-3 hours of listening per week. Midterm and final listening tests. Proficiency requirement for sophomore music majors. Other students admitted with instructor's permission. Repertoire and Listening for Musicians I and II are not prerequisites.

57-290 Repertoire and Listening for Musicians III

Spring: 3 units

This is the culmination of the School of Music's four-semester listening curriculum. Students listen critically to essential music which has stood the test of time and to superior performances. Highlights of this semester's repertoire include units on Middle and Late Beethoven as well as a decade-by-decade survey of the 20th Century. This on-line course features listening and discussion in a virtual coffee shop atmosphere. 2-3 hours of listening per week. Midterm and final listening tests. Proficiency requirement for sophomore music majors. Other students admitted with instructor's permission. Repertoire and Listening for Musicians I-III are not prerequisites.

57-293 Keyboard Studies Test (Degree)

Fall and Spring

This is the keyboard proficiency test which is a requirement for all undergraduate music majors who are not piano majors.

57-294 Beginning Piano Test

Fall and Spring

This is the keyboard proficiency test which is a requirement for all music performance, music composition, music technology, and music theory minors.

57-300 Advanced Bagpipe and Drum Band

Fall and Spring: 3 units

The Pipe Band at Carnegie Mellon is a competitive Grade 3 band in the Eastern United States Pipe Band Association. The band competes at various Scottish festivals and Highland Games during the school year. The band also performs at university activities throughout the year. These include Convocation, Homecoming, Spring Carnival, and Commencement. Other engagements are Spring Concert at CMU and the St. Patrick's Day Parade in Pittsburgh. The band has also played as an opening act for the Pittsburgh Steelers and a Rod Stewart concert.

57-301 Bagpipe History

Intermittent: 3 units

This course covers all types of bagpipe music, including Ceol Mor and Ceol Beag, and studies the prominent composers from MacCrimmon to the present day. Students compose their own material in all time signatures commonly used. The course covers Piobaireachd, Marches, Strathspeys, Reels, Hornpipes, and jigs, as well as harmony and the ability to write out tunes from repetitive listening.

57-302 Bagpipe Construction

Intermittent: 3 units

This course is an in-depth study of Piobaireachd construction, including Primary, Secondary, Tertiary Types A & B, Supplementary Types A & B, and Irregular. The course covers the different patterns in Light Music construction. Students also study the makeup of Pipe Band Medleys and repertoire for competition versus concert.
Prerequisite: 57-307

57-303 Bagpipe Literature and Repertoire

Intermittent: 3 units

This course will cover the origins of the bagpipe and Piobaireachd, bagpipe music in competition, military, and dance. We will also cover major piping competitions, famous bagpipe players, and piping today.

57-304 Bagpipe Maintenance

Intermittent: 3 units

All aspects of bagpipe maintenance are covered in this course, from basic hemping and tying in bags to reeds set-up and manipulation. The course includes study of all types of reeds, cane and synthetic, as well as drone and chanter, and recognition of pipemakers' patterns and distinctive hallmarks.

57-305 Bagpipe Reedmaking

Intermittent: 3 units

This is a hands-on course where the student learns how to make pipe chanter reeds by the traditional method of gouging, shaping, and tying up. This course follows 57-304, Bagpipe Maintenance. Further analysis of chanter and drone reeds will be covered also.
Prerequisite: 57-304

57-306 World Music

Fall: 6 units

An exploration of the diversity and complexity of music from around the world. The class will have three sections: 1. Classical music from India, Iran, Indonesia, and Asia; 2. Native and folk music from Africa, Europe, Australia, and the Americas; 3. The influence of world music on Western classical music. This class will include some reading, listening to CDs, watching videos, and papers and/or presentations. If time permits, there will be special musical activities and invited guests.
Prerequisite: 57-283

57-307 Bagpipe Theory

Intermittent: 3 units

This course prepares students for 57-302, Bagpipe Construction. All aspects of Bagpipe Theory are covered, including time signatures, grand staff, musical rudiments, musical terms and definitions, and writing of simple tunes from memory.

57-308 Bagpipe Advanced History

Intermittent: 3 units

This course is an in-depth study of the origins of the bagpipe, including the oral tradition, the Hereditary Pipers and their teachings, piping in the military, prominent teachers, and a study of the Tree of Piping dating from MacCrimmon to the present day.

57-310 Bagpipe Advanced Literature and Repertoire

Intermittent: 3 units

This course prepares students who have covered all other courses for the Graduate Exam from the Institute of Piping in Scotland. It covers all aspects of theory, history, and practical ability. An in-depth paper should also be prepared by the students in this course on a piping topic of their choice.

57-313 Topics in Movement and Dance: Techniques

Fall: 3 units

This intermediate level course furthers the dance foundation practiced in the first two years of the School of Music movement curriculum. This modern dance technique class will explore momentum based phrase material, body alignment and release, movement dynamics, inversions and floor work. This course focuses on the information and the tools needed to extend movement technique, skills, and performance quality.
Prerequisite: 57-212

57-314 Topics in Movement and Dance: Movement Lab

Spring: 3 units

This intermediate level course will encourage an understanding of dance through the practice of creative improvisation and composition. The course is designed to develop the process of exploration and creation of movement and its performance applications.
Prerequisite: 57-212

57-315 Topics in Movement and Dance

Spring: 3 units

This intermediate level course furthers the dance foundation practiced in the first two years of the School of Music movement curriculum. Classes will encourage an understanding of dance through the practice of creative improvisation and composition. The course is designed to develop the process of exploration and creation of movement and its performance applications.

Prerequisite: 57-212

57-329 Beginning Piano for Minors

Fall and Spring: 3 units

This is a small group lesson for music performance, music composition, music technology, and music theory minors who cannot pass the required beginning piano test.

57-330 Beginning Piano for Minors

Spring: 3 units

This is a small group lesson for music performance, music composition, music technology, and music theory minors who cannot pass the required beginning piano test.

57-331 Principles of Education

Fall: 9 units

This course introduces students to the art and science of being an educator. Content includes views of the academic and social structure of the school, physiological & social characteristics of learners that influence instruction, widely recognized research on learning & teaching, and appropriate & effective class preparation and teaching strategies.

Corequisite: 57-608

57-332 Introduction to Conducting

Fall: 6 units

This course develops the basic skills needed to conduct instrumental ensembles or a small orchestra. It is primarily focused on conducting technique, body language and body coordination and communication. It also deals with learning and translating an instrumental or orchestral score into actual music. The goal is to achieve a clear and communicative technique upon which an artistic interpretation can be built. The student works periodically with a pianist or a small chamber ensemble.

57-333 Band and Choral Arranging

Spring: 6 units

This course presents basic techniques of arranging music for elementary and secondary school choral and instrumental ensembles. Instruments and voices are reviewed for best scoring properties and systematic aural & visual score analyses of repertoire are used to reveal various approaches to scoring ensemble sound.

Prerequisite: 57-153

57-334 Fundamentals of Marching Band

Fall: 3 units

A marching band, due to its visibility and high degree of student involvement, is an integral part of secondary school music programs. The well-schooled music education graduate must have knowledge of this unique form of music performance. This course, designed primarily for those seeking a career in teaching, will accommodate students with no experience and others who have participated in marching band. Among the many areas of concentration will be: philosophy, show charting, marching fundamentals and commands, logistical awareness, and budget formulation. Observation of and active assistance with Carnegie Mellon Kiltie Band will be part of the course content.

57-336 Instrumental/Choral Conducting

Spring: 6 units

This course is a continuation of Introduction to Conducting. The course offers a more detailed conducting technique, adding those subjects related to choral conducting. This is followed by the study and the analysis of interpretation from the point of view of the conductor and ends stressing a set of important practical items, including the psychological attitude and the leadership a conductor must develop as well as the organization and achievement of a fruitful rehearsal technique. The students work periodically with a pianist, a soloist or a chamber ensemble on traditional works and on their own compositions in the case of composition majors.

Prerequisite: 57-332

57-337 Sound Recording

Fall and Spring: 6 units

This course centers around the recording studio in the School of Music: how the studio works, and how to record various types of music, including classical music, using the recording studio and Kresge Recital Hall, which has audio and video links to the recording studio. The method of instruction is to learn by doing, and the goal, from the very first session, is to achieve professional-sounding results. Equipment includes a complete 24-track Pro-Tools system, professionally designed control room that can accommodate up to 24 people, outboard preamps and other gear, and an interesting array of microphones. All recording is direct to hard disc.

57-338 Sound Editing and Mastering

Fall and Spring: 6 units

The raw recording is just the first step in the process of creating a professional finished audio product. "Editing" is the art of piecing together different takes to make one final 'good take.' "Mastering" is the art of polishing the 'good take' to perfection—balancing all the instruments and tracks, adding special effects, setting final levels. If 'recording' seems like an high-energy activity—involving engineers, musicians, producers—'editing and mastering' are the necessary counterparts—long tedious hours of solitary confinement honing the skills of the mastering engineer. Those taking this course are expected to have significant music skills: actively playing a musical instrument (or composition), and/or the ability to read a piano score at the least, and a full orchestra score from any recent century, including our own, at the most. Class attendance is essential; work outside of class is necessary.

Prerequisite: 57-337

57-339 Acting III

Fall: 6 units

This course will build upon the foundation laid in the first year, with a more concentrated look at scene work, an audition workshop that focuses on cold readings as well as monologues, and a character-development project that works to identify specific issues that inhibit freedom on stage. More in-depth work on songs and arias will lead into a musical scene project. The semester will close with a classical text project in which the students will work with verse.

Prerequisite: 57-241

57-340 Acting IV

Spring: 6 units

Continues 57-339 Acting III.

Prerequisite: 57-339

57-343 Interdisciplinary Studies in Listening, Culture, and Technology

Intermittent: 9 units

The proliferation of portable as well as computerized audio technologies has radically changed the way the human beings listen, consume, and produce music and sound. With the emergence of "cloud" storage services like Dropbox, Amazon, and Google you can effortlessly store and share music files anonymously or with friends. Services like Facebook, Pandora, Spotify, Last.fm, Amazon, and iTunes use finely tuned algorithms to make musical recommendations and in the process further personalize your experience as a consumer of music. All of these services, many of which are virtual, have come to mediate our intensely personal and communal experiences with music. The Listening Spaces seminar seeks to understand the overwhelming impact these mediating technologies have had on our social, political and personal interactions with music. Foundational readings will include Jonathan Sterne's MP3: The History of a Format, Alexander Galloway's Gaming: Essays on Algorithmic Culture, Trebor Scholz's Digital Labor: The Internet as Playground and Factory. The seminar will be focused around developing and completing critical projects that cross technological and humanistic boundaries.

57-344 Experimental Sound Synthesis

Intermittent: 9 units

In this course we will explore a variety of experimental approaches to music, sound design, and sonic artwork. Topics will include: composing and mixing in multichannel sound formats, building analog smart-synthesizers, electroacoustic music performance, 3D sound recording, reactive sound environments, sonic sculpture, and beyond. In this course students from a variety of disciplines will work together to design, prototype, and execute a series of ambitious projects. This course is part of the new Integrative Design, Arts, and Technology (IDeATe) program at Carnegie Mellon University and makes use of the new IDeATE@Hunt Media Lab, an adaptable multimedia 'black box' located in the lower level of Hunt Library. Students are expected to be proficient in one or more of the following areas: · Real-time graphical programming environments (Max or PD), · Physical computing platforms (Arduino, Raspberry Pi) · Experimental music composition/performance · Instrument design · Interactive art

57-345 Hacking the Music World

Fall and Spring: 9 units

In this course we will perform a series of real-world experiments that examine new models for music creation, promotion, and distribution. We will produce original music videos, explore social media marketing & optimization, examine new platforms for monetization, and officially release digital albums and apps. The proliferation of digital music distribution has revolutionized how music is experienced in the 21st century. Technologies for music listening, music sharing, and music discovery are in a state of rapid and limitless evolution. There is no longer a single model for a rewarding life in the world of music? we must learn to adapt to the constantly evolving landscape of the 21st century. We must hack the music world! While examining new approaches to distribution and publication, we will also explore the question of how electronic media is redefining our understanding of music-making itself. Does a new album necessarily need to be a fixed set of sound recordings? What if it was a mobile app that reacts to the listener's environment? What if our new album used mutating algorithms to generate new musical experiences every time the listener hits play? Throughout the semester we will form teams combining musicians, software programmers, artists, and entrepreneurs. Our teams will work together to produce new music, to design new music distribution methodologies, and to perform social media experiments that enhance the visibility of our work. Students participating in the course should have proficiency in one or more of the following areas: Social Media Optimization, Music Recording or Video Production, Leveraging Web Application APIs, Mobile Application Design & Implementation. Prerequisites are the IDEATe portal courses or permission of the instructor. Please note that there will be a lab usage fee associated with this course.

Prerequisites: 15-104 or 60-223 or 16-223 or 18-090 or 62-150

57-347 Electronic and Computer Music

Fall: 6 units

This course builds on the concepts learned in Introduction to Music Technology (57-101) and gives added knowledge in the areas of composition using digital and analog devices as well as various computer programs. Building computer models of both analog and digital synthesizers as well as drum machines, loop players and various other sound processing effects will be covered in detail. Students will be required to produce several projects throughout the course demonstrating their understanding of various concepts in electronic music. More emphasis is placed on the overall quality of the end musical product than in 57-101 in order to prepare students for music production in a professional setting.

Prerequisites: 57-171 or 57-101

57-349 Supervised Theory Teaching

Fall and Spring: 6 units

This course provides teaching skills in theory for students who have already completed the theory program at Carnegie Mellon University or who have demonstrated theory competence. The students will attend all sessions of the assigned theory class and will assist the professor by correcting homework, delivering a short lecture, developing a class syllabus and tutoring individual students. The work is done under direct supervision and advice from the regular professor who is always present in the class. Enrollment limited to a maximum of two students per class.

57-350 Dalcroze Piano Improvisation

Fall and Spring

These courses are required for candidates in the Dalcroze Certification program. They are designed to develop keyboard improvisation skills necessary for teaching Eurhythmics.

57-351 Dalcroze Piano Improvisation

Fall and Spring

These courses are required for candidates in the Dalcroze Certification program. They are designed to develop keyboard improvisation skills necessary for teaching Eurhythmics.

Prerequisite: 57-350

57-352 Dalcroze Piano Improvisation

Fall and Spring

These courses are required for candidates in the Dalcroze Certification program. They are designed to develop keyboard improvisation skills necessary for teaching Eurhythmics.

Prerequisite: 57-351

57-353 Dalcroze Piano Improvisation

Fall and Spring

These courses are required for candidates in the Dalcroze Certification program. They are designed to develop keyboard improvisation skills necessary for teaching Eurhythmics.

Prerequisite: 57-352

57-355 Secondary Guided Teaching

Spring: 3 units

This course enables students to apply instructional strategies in local secondary school music classes. School visits provide opportunities to work with band, choral, & orchestral ensembles and general music classes. Seminar discussions with the cooperating teachers familiarize students with both school-wide and classroom management issues that affect teaching, learning, motivation, and the administration of music programs.

Prerequisites: 57-362 and 57-363 and 57-375 and 57-361 and 57-360 and 57-356 and 57-336 and 57-332 and 57-607 and 57-608

Corequisite: 57-376

57-356 Elementary Guided Teaching

Fall: 3 units

This is the second level of field experience in the public schools. This course provides for observation and closely supervised teaching experiences with elementary age children in a school setting.

Corequisite: 57-375

57-359 Career Strategies for Musicians

Intermittent: 3 units

This course will assist students in developing the necessary expertise and materials to transition successfully from music student to professional musician. Four major areas will be covered: 1.) The multifaceted activities of today's professional musicians, individual assessments to determine strengths and challenges related to these activities, and strategies for addressing challenging areas; 2.) Developing promotional materials for entrepreneurial and salaried opportunities. Entrepreneurial materials include business cards, letterhead, photo, bio, performance resume, email list, press release, flyers, grant proposals, demo CD and website. Salaried materials include an employment resume and cover letter; 3.) Self-employment considerations, including budgeting, taxes, health insurance, and unions; and, 4.) Communications, including handling auditions, introducing pieces, introducing group members, and pitching ideas. You have the talent, determination, and work ethic to succeed. Now learn the marketing, business and communications skills to close the gap.

57-360 Brass Methods

Fall: 3 units

This music education course develops basic brass playing and teaching techniques for beginning and intermediate instrument classes. The course includes training in beginning band program design, aural & visual diagnosis of individual and ensemble playing problems, and methods of accelerating music reading independence in young players. The course requires two off-campus field teaching experiences in local schools. Each field teaching experience will require about 3 hours to complete — students should allow enough time in their schedules to complete this requirement.

57-361 Percussion Methods

Fall: 3 units

This class gives the non-percussion major a background in the fundamentals of teaching percussion. The main focus of the course is snare drum. The students spend most of their time learning the basic concepts of beginning snare drum so they will be prepared to teach beginning students of any grade level. Much time is devoted to proper stance, grip, and stroke in order to insure a good foundation for a beginning student. Also covered are the various mallet instruments, timpani, and all small hand percussion. Students will learn about purchasing proper equipment for the various levels of learning in common school programs.

57-362 Woodwind Methods

Spring: 3 units

This music education course develops basic woodwind playing and teaching techniques for beginning and intermediate instrument classes. The course includes training in beginning band program design, aural & visual diagnosis of individual and ensemble playing problems, and methods of accelerating music reading independence in young players. The course requires two off-campus field teaching experiences in local schools. Each field teaching experience will require about 3 hours to complete — students should allow enough time in their schedules to complete this requirement.

57-363 String Methods

Spring: 3 units

String Methods prepares music educators for work in the public schools. A major portion of class time will be applied to violin and cello techniques. Upon completion of the course, the student will be expected to demonstrate the technical skills of a second year beginning string student. Students will also be introduced to various method books, string supplies, and repairs.

57-364 Conducting Practicum

Fall and Spring: 3 units

This course provides applied conducting experience for the conducting minor.

57-370 Stage Direction

Spring: 3 units

This course provides an internship working with a middle or high school music theater production. Students may participate in coaching, direction, and choreography. In addition, they keep a journal of their experience and submit a final paper describing what they have learned from working with the teachers or professional directors who were responsible for the production. It is suggested that this course be taken during the spring semester when most music theater productions are scheduled.

57-374 Music in the Urban School

Fall and Spring: 9 units

This course will involve workshops with nationally known instructors in eurhythmics, world drumming, contemporary popular music, and classroom management. The course will require attendance at workshops, classroom observations and closely supervised teaching experiences. Schools involved are all inner city schools with a poverty level of 75% or above. This course is offered as the result of a grant received from the Federal Department of Education by the School of Music, the Pittsburgh Public Schools, and the Wilkinsburg School District.

Prerequisite: 57-331

Corequisite: 57-356

57-375 Music in the Elementary School

Fall: 6 units

This course is designed to provide a philosophical background for teaching music in the elementary school and to provide a variety of pedagogical techniques, which are essential when teaching music from Preschool through Grade 6.

Prerequisite: 57-331

Corequisite: 57-356

57-376 Music in the Secondary School

Spring: 6 units

This course covers a variety of topics related to the development and the management music programs in secondary schools. Emphasis is placed on the leadership, classroom management, general music & performance course content, and routine administrative planning.

Prerequisite: 57-331

Corequisite: 57-355

57-377 Psychology of Music

Intermittent: 9 units

Music cognition is an interdisciplinary approach to understanding the mental processes that support musical behaviors, including perception, comprehension, memory, attention, and performance. Like language, music is a uniquely human capacity that arguably played a central role in the origins of human cognition. This course is survey of current approaches to and theories about the perception and cognition of music. Topics covered include psychoacoustics; the cognitive neuroscience of music; relationships between music and language; the nature of musical knowledge; and debates about aesthetics, evolutionary psychology, and musical universals. At the end of this course a student should be able to identify key theories and hypotheses in music cognition as they relate to memory, emotion, physiology, neurology, acoustics, language, and evolution. They will be able to comparatively evaluate hypotheses and place them in an intellectual context. These objectives will be achieved through critical reading, discussions, and written exercises. There are no prerequisites for this course. It will be helpful for you to know some basic elements of music theory (such as the names for chords, Roman numerals, and so on), but some extra help will be available to cover these topics. Some notational basics will be covered in the first lecture.

57-381 Collaborative Piano I

Fall and Spring

This class is the first in a series of hands-on courses which allow the student to accumulate experience accompanying in a professional venue. Students will be assigned to a vocal and/or instrumental studio and will have the opportunity to coach repertoire with a professional accompanist. Assignments may include playing for instrumental juries.

57-382 Collaborative Piano II

Fall and Spring

Continues 57-381 Accompanying I.

Prerequisite: 57-381

57-383 Collaborative Piano III

Fall and Spring

Continues 57-382 Accompanying II.

Prerequisite: 57-382

57-384 Collaborative Piano IV

Fall and Spring

Continues 57-383 Accompanying III.

Prerequisite: 57-383

57-385 Collaborative Piano V

Fall and Spring

Continues 57-384 Accompanying IV.

Prerequisite: 57-384

57-386 Collaborative Piano VI

Fall and Spring

Continues 57-385 Accompanying V.

Prerequisite: 57-385

57-391 Keyboard Studies (Music Ed)

Fall and Spring: 3 units

This course develops piano skills necessary for work in the elementary and secondary schools. Special emphasis is placed on transposition, score reading, harmonization and sight-reading. This course is required for all music education majors.

Prerequisite: 57-191

57-392 Keyboard Studies (Music Ed)

Fall and Spring: 3 units

Continues 57-391 Keyboard Studies V. This course is required for all music education majors.

Prerequisite: 57-391

57-393 Keyboard Studies Test (Music Ed)

Fall and Spring

This is the keyboard proficiency test which is a requirement for all undergraduate music majors who are music education minors.

57-399 Music-Cinema-Culture

Intermittent: 9 units

The first 100 years of the 20th Century's only original art form, whose advent has brought about tremendous social and cultural changes. Students view selected films, learning first the basics of film theory, cinema's working structures and the function of music. Ultimately, they are able to analyze, in the form of a written essay, the function and value of the music in a particular film and the impact such music has had on society.

57-408 Form and Analysis

Spring: 6 units

This course provides a working understanding of all styles and genres of Western classical and contemporary repertoire. Students will explore various aspects of the compositional process, from basic organizational structures to the details of individual musical phrases. They will learn to see and to hear the most important compositional features of a piece of music and will develop a deeper understanding of the music they perform, conduct, and compose.

Prerequisite: 57-151

57-412 Opera Since Wagner

Intermittent: 9 units

In the 400-year arc of opera history, the last 125 years have seen the genre's apogee, perigee, and current renaissance. Between the Wagnermania of the late nineteenth century and today's vogue for both opera and "popera," new opera production slowed greatly in the third quarter of the last century as composers rejected its traditions and audiences turned increasingly to rock and pop. In this course, we will survey this trajectory by viewing and analyzing eight repertoire staples: Wagner Parsifal Debussy Pelléas et Mélisande Puccini Turandot Berg Wozzeck Gershwin Porgy and Bess Britten Peter Grimes Messiaen Saint François d'Assise Reich Three Tales We will also become acquainted with other works related to these staples, from Strauss to Saariaho and Tan Dun, and ask numerous questions. What can these operas' characters and techniques tell us about late modern subjectivity? What happened to the great national traditions? In what musical styles has opera flourished and languished? How have audiences changed? How has the notion of opera itself changed, from the nature of its heroes and heroines to its performance forces and media? The goals of this course are to 1) promote intimate knowledge of the eight core operas; 2) encourage familiarity with numerous related opera plots, opera composers, and twentieth- and twenty-first-century musical styles; 3) broaden literary and musical analytical tools to include historical, aesthetic, and (multi)cultural perspectives on opera; and 4) improve oral and written communication skills about opera. Requirements: Attendance at opera screenings, readings, quizzes, small written assignments, and a 17 to 20-page research paper on an opera of your choice written since 1850. Required text: Mervyn Cook, ed. The Cambridge Companion to Twentieth-century Opera (2005). Prerequisite: 57-284

57-413 The Interpretation of Music

Intermittent: 6 units

What does it mean to "interpret" music? How does performance differ from interpretation? How do we distinguish a good interpretation from a bad one? To answer these questions, this course examines Metaphor, History, Influence, Meaning, Analysis, Performance, Musicology, and other concepts, applying them to works like the Mendelssohn Violin Concerto, Chopin's Fantasia Impromptu, Beethoven's "Ghost" Trio, and Debussy's "Voiles." Our readings draw mainly from Lawrence Kramer's *Interpreting Music* (2011). Our goal is to appreciate the complexity and nuance inherent in the process of music making and to formulate our individual values in the interpretation of music.

57-414 Music and Nature

Intermittent: 9 units

Musicians and philosophers have long explored the rapport between music and nature, tracing music's origins alternatively to nature and human culture and defining nature differently according to their time and place. This course will examine the opposition between nature and culture through both musical compositions and philosophical writings. We will study theories of the origin of music (from Lucretius to biomusicology), theories of music that seek justification by appealing to nature (from Boethius to Grisey), and theories that question whether natural sounds can be music. We will also examine musical representations of place, weather, and animals through the perspectives of ecocriticism and notions of the pastoral. Repertory will include Vivaldi's "Spring" Concerto, Beethoven's "Pastoral" Symphony, Wagner's Ring of the Nibelung, Mahler's Symphony No. 3, and Debussy's La Mer. We will compare landscapes by Sibelius and Copland, birds by Dvorak, Bartók, Ravel, Stravinsky, and Messiaen, and whales by Crumb and Hovhanness. We will also treat statements on the environmental crisis by composers Harrison Birtwistle, Philip Glass, Peter Sculthorpe, and John Luther Adams. Reading, listening, discussion, 2 short papers, 1 long paper, oral presentation.

Prerequisite: 57-285

57-415 Mozart Operas

Fall: 6 units

In the genre with the highest stakes and the highest failure rate, Mozart composed the earliest operas to have staked a permanent place at the center of the repertory. This course seeks to account for his success, to explain why he succeeded where others failed and what has made his operas beloved for over 225 years. We begin with a brief overview of all of Mozart's operas and discuss the types of opera in circulation in late 18th century Austro-Hungary, especially opera seria, opera buffa, and Singspiel, and the pressures that shaped the music and libretto of each production, from the type of patronage to the style of recitative. Then we examine *The Marriage of Figaro*, *Don Giovanni*, and *The Magic Flute* at a pace of about one act per class session, looking at poetry, dramaturgy, stagecraft, acting, performance practice, character development, theme, and politics, always through the filter of Mozart's music, especially its melody, reform elements, blurring of genre and affect, vocal counterpoint, use of topics, and musical symbolism.

Prerequisite: 57-285

57-416 Globalization of Classical Music: USA, Turkey, Japan

Intermittent: 6 units

What sounds are made when cultures clash? What issues are at stake when composers and performers approach music with strong ties to music of other cultures, such as Debussy's Iberia and Copland's El Salon Mexico, or when, like Bartok, they introduce elements of a stylized folk music into the concert hall? How did the Western classical tradition come to be mastered in countries worldwide? Where is it resisted and why? When composers from non-Western traditions engage with classical traditions, what do they give up and what do they gain? In what ways do they seek to retain style traits or instruments from their home country? and why? Do countries all adopt this tradition in the same way and for the same reasons? How do such varied negotiations of cultures define national identities? This course addresses such questions by focusing on the role of Western classical music in the history of the United States, Turkey, and Japan - countries with very different histories of engaging with European culture, yet sharing a decisive adoption of European-based modernity in the twentieth century.

Prerequisite: 57-285

57-417 Major Vocal Performance Ensemble

Fall and Spring: 6 units

There are two choral ensembles. Concert Choir is a select ensemble of approximately 40 voices of superior vocal/musical talent and experience in the choral idiom. Performance requirements are more stringent than those of the Repertory Chorus. Repertory Chorus is an ensemble of undetermined size. Emphasis is placed on vocal technique and development, musical skills in the rehearsal with minimum performance requirements. Audition required.

Corequisites: 57-522 or 57-521 or 57-509 or 57-502 or 57-501 or 57-500

57-418 Major Instrumental Ensemble

Fall and Spring: 6 units

There are two instrumental ensembles: Orchestra and Wind Ensemble. Rotating seating plans, within and between ensembles, will prevail at the discretion of the Director of Orchestral Studies and the Director of the Wind Ensemble. The instrumental faculty will be consulted. All music majors who are required to enroll in an instrumental ensemble must audition for placement and enroll in Major Instrumental Ensemble. Audition required. Corequisites: 57-522 or 57-521 or 57-520 or 57-519 or 57-517 or 57-516 or 57-514 or 57-513 or 57-512 or 57-511 or 57-510 or 57-509 or 57-508 or 57-507 or 57-506 or 57-505 or 57-503 or 57-502 or 57-501

57-420 Jazz Vocal Ensemble

Fall and Spring: 3 units

A highly selective group of mixed voices who perform contemporary jazz and pop vocal arrangements. Open to all CMU students. Audition required. Prerequisite: 57-420

57-423 Repertoire Orchestra

Fall and Spring: 3 units

This course thoroughly acquaints participants with the standard works one would expect to encounter as part of a career as an orchestral player. Assigned repertoire will be read each class session. All students are eligible to register for this course by special permission. Students who are not placed in the Carnegie Mellon Philharmonic are given priority for registration.

57-424 Percussion Ensemble

Fall and Spring: 3 units

This ensemble is open to all percussion majors.

57-428 Theatre Orchestra

Intermittent

Instrumental ensemble which accompanies vocal productions in the School of Music or the School of Drama.

57-429 Beginning Piano for Children

Fall and Spring: 6 units

This course is the first of two courses in a year-long internship in the piano teaching of young children, combining class and private instruction: a study of the basic teaching/learning process as applied to piano teaching, covering comprehensive step-by-step presentation in reading, rhythm, ear training, sight reading, technique, and musicianship. Under supervision, students will teach the weekly group class and private lessons. Weekly conferences will be held for learning the presentation of materials for class teaching, analyzing pedagogical problems, and developing communication skills with both young pupils and their parents.

Prerequisite: 57-273

57-430 Music of Iran

Intermittent: 9 units

The Iranian civilization is one of the oldest continuing civilizations in the world. Music has played an important role in the continuation and preservation of this ancient culture. In this course, the traditional, folk, and contemporary music of Iran will be studied and discussed. The focal point of the course will be the Persian modal system, the Dástgâh. Starting with a historical survey of the ancient and medieval Persian music, different aspects of the Dástgâh system will be demonstrated and discussed. In addition, religious music and folk music of Iran as well as Iranian contemporary music will be discussed during the course.

57-431 Italian Literature and Repertoire

Spring: 3 units

The course provides a bibliography of repertoire in the Italian language. Material will include art songs and cantatas and will be presented via individual student performances in class, listening to recordings and group survey of repertoire. Reading and writing assignments will serve to establish historical perspective as well as programming considerations.

57-432 French Literature and Repertoire

Spring: 3 units

This course examines French songs for solo voice. Representative works from 18th through 20th centuries will be studied in the context of music history, style and programmatic considerations. Classes consist of individual performance, listening to recordings, and group survey of repertoire. Reading and written assignments establish historical perspective as well as programming considerations.

57-433 Musical Theatre Literature and Repertoire

Fall: 3 units

This class covers music theatre repertoire for two semesters, beginning chronologically with the operetta and concluding with current theatre composers. Each student will be assigned songs to prepare from these musicals. These songs can also be used for music theatre auditions. Students are expected to research all assigned songs and perform them in the proper style. Notebooks must be kept which include all lecture notes, class song assignments and music for songs performed individually.

57-434 Musical Theatre Literature and Repertoire

Spring: 3 units

Continues 57-433 Musical Theatre Literature and Repertoire.

Prerequisite: 57-433

57-435 German Literature and Repertoire

Spring: 3 units

The course examines German repertoire composed for solo voice. Representative works from the Baroque period through the 20th Century are studied in the context of musical style, vocal demands and programmatic considerations. Repertoire focuses on art songs and cantatas, but also includes certain oratorio excerpts, which are included frequently in recital programs. A bibliography of German repertoire is compiled through individual or group performance of songs, listening to recordings and through research assignments, the latter of which focuses upon the works of specific composers. Reading assignments are included to establish an historical perspective.

57-436 English/Contemporary Literature and Repertoire

Spring: 3 units

The course provides a bibliography of repertoire in the English language. Material will be limited to art songs and will be presented via individual student or group performances in class, and recorded performances. Research assignments will be required for selected anthologies or for works by specific composers. Repertoire will be examined according to vocal requirements, musical style, and programmatic function. The repertoire will consist primarily of works by British and American composers, but works by Russian and Spanish composers will also be included.

57-437 Literature and Repertoire

Fall and Spring: 3 units

This course deals with literature and repertoire for orchestral instruments. There are multiple sections organized by instrument categories or specific instruments.

57-438 Multitrack Recording

Fall and Spring: 9 units

This course builds upon the ideas learned in Sound Recording (57-337), but with an emphasis on close microphone techniques and popular music styles. Students will work in small groups and complete at least two recording projects. \$10.00 materials fee.

Prerequisites: 57-341 or 57-337 or 57-357

57-441 Analysis of 19th Century Music

Intermittent: 9 units

This course will provide students with a variety of tools for the analysis of music from Schubert to Mahler and early Schoenberg. The primary emphases will be on small-scale (chord-to-chord) harmonic organization, on the larger-scale organization of tonal centers, and on form, but other issues will also be explored (e.g. rhythm and meter, text/music relations). The course will sample a wide range of repertoires, including solo piano music, orchestral music, and opera, and it will have a special emphasis on chamber music including the German Lied.

57-442 Analytical Techniques

Fall: 9 units

Analytical Techniques is an upper level music support course for juniors and seniors who have completed the undergraduate required music theory curriculum in harmony and counterpoint. Studying the principles of Piston, Forte, Schenker and other important music theorists, students will learn to use whatever analytical techniques are best suited to better understand each individual piece. The primary goal of the course is to develop independent skills in analyzing their own repertoire as performers, conductors, composers, and teachers.

Prerequisite: 57-408

57-444 Principles of Counterpoint

Intermittent: 9 units

This course explores the development of Western music composed with multiple independent parts. The first half of the course traces the history of part-writing from medieval organum to the twenty-first century. Emphasis is given to study of pre-Baroque and twentieth-century music, and to the conceptual shifts that occurred moving in and out of the common-practice period. The second half of the course examines, across multiple musical styles, specific contrapuntal techniques such as imitation and ground bass forms. Assignments include both writing exercises and analysis, culminating in a term project on a topic selected by the student.

Prerequisite: 57-408

57-445 Counterpoint in 18th Century Composition

Intermittent: 6 units

In this course the student will study how to write two-part counterpoint within the harmonic framework of 18th-century instrumental music. The focus of study will be J.S. Bach's inventions, and writing will be directed towards composing several complete inventions in that style. Prerequisites: Harmony I and Harmony II or permission of the instructor. This course is designed for composers, theory minors, Bach lovers, keyboard majors, and anyone who wants to seriously sharpen their tonal writing skills.

57-446 Renaissance Counterpoint

Intermittent: 6 units

In this course the student will study how to write vocal counterpoint using the classic "species" approach, based on the style of Renaissance masters Palestrina, Lassus, and Victoria. The latter part of the course will extend the study to instrumental music of the 16th century, and explore the development of chromaticism in avant-garde composers of the time. Reading about and listening to Renaissance music and composers will be included as background context for the theory work. Daily writing exercises in the first part of the course will lead to a term project producing a performable piece of music by the end of the semester. This course is designed for composers (both for writing technique and college teaching preparation), theory minors, early music lovers, choral singers and conductors, church musicians, and anyone who wants to sharpen their writing skills. Prerequisite: Harmony I or permission of the instructor (demonstrated competence in reading treble and bass clef, and intervals).

Prerequisite: 57-153

57-447 Harp Pedagogy

Fall and Spring: 3 units

TBA

57-448 Brass Pedagogy

Fall: 3 units

In this course we introduce the "Art of Teaching". In this case, to teach, develop and encourage young brass players just starting an instrument or who are in their early stages of development. Concepts of basic brass pedagogy will involve the following topics: Music as Metaphor; Teaching young students; Listening; Developing a Concept of Sound; Posture; Breathing; Embouchure; Articulation: Single Tonguing, Multiple Tonguing; Mouthpiece playing; The Warm-up; Slurring; Intonation; The Upper Register; Endurance; Vibrato; Dental Braces; Orchestral Playing; Performance Preparation; Taking Auditions Brass students will leave CMU with a basic understanding of the pedagogical needs and requirements of beginning and inexperienced students, so that they may begin private teaching studio upon graduation.

57-449 Beginning Piano for Children

Fall and Spring: 6 units

This course is the second of two courses in a year-long internship in the piano teaching of young children, combining class and private instruction: a study of the basic teaching/learning process as applied to piano teaching, covering comprehensive step-by-step presentation in reading, rhythm, ear training, sight reading, technique, and musicianship. Under supervision, students will teach the weekly group class and private lessons. Weekly conferences will be held for learning the presentation of materials for class teaching, analyzing pedagogical problems, and developing communication skills with both young pupils and their parents.

Prerequisite: 57-429

57-450 Audience Development

Intermittent: 6 units

TBA

57-451 Teaching Artist Training

Intermittent: 6 units

TBA

57-452 Audience Engagement in Action

Intermittent: 6 units

Responding to requests from the Pittsburgh community, Audience Engagement teams spearhead innovative performance projects that serve organizations such as the CMU Philharmonic, Pittsburgh Symphony, Hillman Cancer Center, Carnegie Carnegie Hall, and the Pittsburgh Parks Conservancy, among others. A strong résumé builder, this course offers business connections and professional experience. No prerequisites.

57-454 Stagecraft I: beyond the performance

Intermittent: 3 units

This course will teach skills that are essential to your success on the stage and beyond, including stage presence, attire and etiquette, public speaking, taking auditions, receptions, programming, and more. Music majors may take this course as individuals or together as, for example, a chamber music ensemble.

57-455 Shaping Time in Performance

Intermittent: 9 units

This course will look at basic questions that performers face: Which level of pulse do I want to feel as the main one? How can I shape a pulse expressively? Which measure in a phrase is felt as a main goal, especially when the phrase contains an unusual number of measures? How can multiple tempi be meaningfully related? Among many important formal arrival points, which are the most important? In addition to these questions, we will also look at recent work on ways in which 18th-century musicians may have understood meter very differently from most musicians today. These alternate perspectives open new possibilities for hearing and shaping the flow of musical time in baroque and classical music. These issues will be pursued from two directions. We will develop simple theoretical tools that can make score analysis a helpful input to the decisions that performers make about such questions. We will also examine audio and video recordings by famous artists to see both how they dealt with these issues and what new questions are raised. Week-to-week work will include reading, listening, and score analysis. Students will write term papers that either use one of the main perspectives developed in class (starting from scores or starting from recordings) or else combine the two. They will also give presentations about their projects to the class.

57-456 Communication and Marketing

Intermittent: 6 units

What is your message? Who is your audience? How do you reach them? These are among the topics we'll explore in this course. Group projects and case studies help us identify the key aspects of one of the most important aspects of any music career. Being a great musician won't do you any good if no one knows you exist! By the end of the semester, students should be able to understand such concepts as branding, marketing, reach and advertising; identify audience segments and target messages to those segments; create compelling marketing materials, including bios, group and program descriptions, websites and flyers; work with teams to try out a variety of marketing strategies in real-world circumstances; learn to capitalize on social media and use it to effectively build and communicate to an audience; learn to write effective and powerful marketing copy (bios, sales pieces, etc.); examine competitors and market leaders to look for opportunities and best practices.

57-459 Score Reading/Keyboard Harmony

Spring: 6 units

This course is for pianists, organists, and other musicians with good keyboard skills. It is a practical, hands-on learning experience. Students learn by doing and observing other students. All work is done at the keyboard.

Prerequisite: 57-408

57-463 Eurhythmics for Non-Majors

Fall: 6 units

Rhythm is about time and timing. Dalcroze Eurhythmics is an exploration of the rhythm inside us. Experiencing rhythm through music and movement brings awareness and understanding of our own inner rhythm as well as rhythm in all the arts and beyond. This class is for juniors and seniors only.

57-464 Eurhythmics Applications for Non-Majors

Fall: 6 units

Rhythm is about time and timing. Dalcroze Eurhythmics is an exploration of the rhythm inside us. Experiencing rhythm through music and movement brings awareness and understanding of our own inner rhythm as well as rhythm in all the arts and beyond. This class is for juniors and seniors only.

57-465 Eurhythmics Applications for Performing and Teaching

Fall: 6 units

Rhythm is about time and timing. Dalcroze Eurhythmics is an exploration of the rhythm inside us. Experiencing rhythm through music and movement brings awareness and understanding of our own inner rhythm as well as rhythm in all the arts and beyond. For musicians, meaningful rhythmic movement reinforces understanding of music concepts while focusing awareness on the physical demands of artistic performance. This approach to musical problem solving is applicable also to studio and classroom teaching.

Prerequisite: 57-164

57-466 Eurhythmics Applications for Performing and Teaching

Fall: 6 units

Rhythm is about time and timing. Dalcroze Eurhythmics is an exploration of the rhythm inside us. Experiencing rhythm through music and movement brings awareness and understanding of our own inner rhythm as well as rhythm in all the arts and beyond. For musicians, meaningful rhythmic movement reinforces understanding of music concepts while focusing awareness on the physical demands of artistic performance. This approach to musical problem solving is applicable also to studio and classroom teaching.

Prerequisite: 57-164

57-467 Production: Crew

Intermittent: 3 units

To be determined by the department

57-468 Production: Crew

Spring: 3 units

TBA.

57-469 Production: Scenes

Fall: 6 units

Preparation of operatic and musical theatre scenes with a public performance of the scenes at the end of the semester. Specific repertoire based upon the proficiency of the individual student.

Prerequisites: 57-212 and 57-340

57-470 Production: Scenes

Spring: 6 units

Preparation of operatic and musical theatre scenes with a public performance of the scenes at the end of the semester. Specific repertoire based upon the proficiency of the individual student.

Prerequisites: 57-212 and 57-340

57-471 Production: Performance

Fall: 6 units

Preparation of an operatic or musical theatre production with a fully staged public performance of the production at the end of the class.

Prerequisites: 57-212 and 57-340

57-472 Production: Performance

Spring: 6 units

Preparation of an operatic or musical theatre production with a fully staged public performance of the production at the end of the class.

Prerequisites: 57-212 and 57-340

57-477 Music of the Spirit

Intermittent: 6 units

This is a guided listening course which surveys musical explorations of spirituality. While the majority of repertoire will be from the Western Classical tradition, musics of a variety of cultures will be included. The music will be organized by particular religious traditions and by universal themes, such as community, death/afterlife, birth/new birth, martyrs/ heroes, transcendence/immanence, meditation/contemplation/trance, etc. Most course materials, including streaming audio, are online, with one meeting per week in the classroom. Will include participatory introductions to numerous forms of chant. Requires oral and written reports.

57-478 Survey of Historical Recording

Intermittent: 6 units

Through an intensive listening regimen, illustrated virtual lectures, discussion, and projects, this online course introduces major performing artists and highlights major developments in music media. The emphasis is on classical recordings. But there will also be excursions into influential and iconic popular artists.

57-480 History of Black American Music

Fall: 6 units

Come and explore the rich musical heritage of Black America. This course will survey the music of Black America beginning with the African legacy and continuing through the music of the Twentieth Century. Class sessions will involve discussions, listening, viewing of films, and reports by students on topics of individual interest. Discussions will involve, historical, cultural and political perspective, as well as the music and composers themselves. Lecturing will be at a minimum. Innovative testing in quiz show format will be used. No prerequisites required. Open to upper level undergraduate students.

57-487 Advanced Solfege III

Fall: 3 units

Covers the same concepts as Solfege IV in more challenging material, from Bach chorales in open score to excerpts by Bartok, Honegger, Stockhausen, or Boulez. Dictations are three-part contrapuntal and difficult harmonic three and four parts.

Prerequisite: 57-186

57-488 Advanced Solfege IV

Spring: 3 units

Continues 57-487 Advanced Solfege III.

Prerequisite: 57-487

57-496 Minor Studio

Fall and Spring

A 45-minute private lesson per week for all music performance minors. There is a fee for the lessons.

57-497 Minor Studio

Fall and Spring

A 45-minute private lesson per week for all music performance minors. There is a fee for the lessons.

57-498 Minor Studio

Fall and Spring

A 45-minute private lesson per week for all music performance minors. There is a fee for the lessons.

57-499 Minor Studio

Fall and Spring

A 45-minute private lesson per week for all music performance minors. There is a fee for the lessons.

57-500 Major Studio (Voice)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-501 Major Studio (Piano)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-502 Major Studio (Organ)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-503 Major Studio (Harp)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-505 Major Studio (Violin)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-506 Major Studio (Viola)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-507 Major Studio (Cello)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-508 Major Studio (Double Bass)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-509 Major Studio (Guitar)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-510 Major Studio (Flute)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-511 Major Studio (Oboe)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-512 Major Studio (Clarinet)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-513 Major Studio (Bassoon)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-514 Major Studio (Saxophone)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-515 Major Studio (Horn)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-516 Major Studio (Trumpet)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-517 Major Studio (Trombone)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-518 Major Studio (Euphonium/Baritone)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-519 Major Studio (Tuba)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-520 Major Studio (Percussion)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-521 Major Studio (Composition)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-522 Major Studio (Bagpipe)

Fall and Spring: 9 units

A one hour private lesson per week for all music majors.

57-570 Music and Technology Seminar

1 unit

Missing Course Description - please contact the teaching department.

57-571 Music and Technology Project

Fall and Spring: 12 units

TBA

57-572 Music and Technology Project

Fall and Spring: 12 units

TBA

57-597 Senior Project

Fall and Spring

A composition for orchestra required of all senior composition majors.

57-598 Junior Recital

Fall and Spring

A half recital required of all junior performance majors.

57-599 Senior Recital

Fall and Spring

A full recital required of all senior performance majors.

57-603 Practice Teaching (Elementary)

Fall and Spring

Experience in working with elementary students in a public school setting. The teaching is supervised by an experienced public school teacher and members of the CMU music education faculty.

Prerequisites: 57-355 and 57-393

57-604 Practice Teaching (Secondary)

Fall and Spring

Experience in working with secondary students in a public school setting. The teaching is supervised by an experienced public school teacher and members of the CMU music education faculty. Students may choose a vocal or instrumental emphasis in the secondary placement.

Prerequisites: 57-355 and 57-393

57-607 Vocal Methods

Spring: 3 units

This course enables each student to develop a pleasant, healthy, and musically expressive voice and to develop effective vocal pedagogy.

57-608 Observation

Fall: 3 units

This music education offering is an independent study course designed to introduce students to a range of K-12 instructional practices through observation of elementary and secondary school teachers. Students will identify strategies that impact learning in the areas of pedagogy, student motivation, classroom management, and accommodations for special learners. Students complete this course by arranging 20 prescribed classroom observations in local schools - multiple observations may be completed at each school visit. In order to complete the observations in one semester, students should schedule an open 3-hour time block one day per week between 8 am and 3 pm.

Corequisite: 57-331

57-610 Internship

Fall and Spring

A student can receive credit for an unpaid internship in a music related field. The amount of credit is determined by the number of internship hours.

57-611 Independent Study in History

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-612 Independent Study in Theory

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-613 Independent Study in Research

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-614 Independent Study in Performance

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-615 Independent Study in Electronic and Computer Music

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-616 Independent Study in Literature and Repertoire

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-617 Independent Study in Sound Recording

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-618 Independent Study in Conducting

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-619 Independent Study in Opera

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-620 Independent Study in Solfege

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-621 Independent Study in Eurhythmics

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-622 Independent Study for Competitions

Fall and Spring: 3 units

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-623 Independent Study in Diction

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-624 Independent Study in Theater Composition

Fall and Spring

Students undertake a critical examination of some aspects of music on an independent basis under the supervision of a full-time faculty member. They choose their topic and contract with the Project Director (faculty sponsor) as to when and how the project will be completed. Open to upperclassmen.

57-641 Dalcroze Research Paper

Fall: 3 units

Candidates in the Dalcroze Certification Program are required to submit a research paper based on their understanding of Dalcroze principles based on their experience and supported by appropriate literature.

57-642 Dalcroze Research Paper

Spring: 3 units

Candidates in the Dalcroze Certification Program are required to submit a research paper based on their understanding of Dalcroze principles based on their experience and supported by appropriate literature.

57-691 Dalcroze Pedagogy/Practice Teaching

Fall: 3 units

This course gives hands-on experience in applying Dalcroze principles in teaching situations. It is designed for students interested in learning about the teaching of Eurhythmics, general Music Education, and for those considering the Dalcroze Certificate. The class will meet in a three week rotation of two Thursday evenings followed by a Saturday morning with the Preparatory School children's classes.

57-692 Dalcroze Pedagogy/Practice Teaching

Spring

This second semester of a two semester course focuses on applications of Dalcroze pedagogy and practice teaching with upper elementary and middle school age students.

Naval Science - ROTC Courses

32-100 Naval Laboratory

Fall and Spring: 3 units

Military drill, physical fitness, and leadership seminars.

32-101 Introduction to Naval Science

Fall: 6 units

A general introduction to the naval profession and to concepts of Seapower. Instruction emphasizes the mission, organization, and warfare components of the Navy and Marine Corps. Included is an overview of officer and enlisted ranks and rates, training and education, and career patterns. The course also covers naval courtesy and customs, military justice, leadership, and nomenclature. This course exposes the student to the professional competencies required to become a naval officer.

32-102 Seapower and Maritime Affairs

Spring: 6 units

This course surveys US naval history from its European origins to the present with emphasis on major developments and the geopolitical forces shaping these developments. Also included is discussion of the theories and writings of naval historian and strategist Alfred Thayer Mahan. The course will finish by covering present day concerns in seapower and maritime affairs including the economic and political issues of merchant marine commerce, the law of the sea, the navy and merchant marine of the former Soviet Union (FSU), and a comparison of US and FSU maritime strategies to include the rise and decline of the Soviet Navy.

32-200 Naval Laboratory

Fall and Spring: 3 units

Military drill, physical fitness, and leadership seminars.

32-201 Leadership & Management

Fall: 9 units

This course is a comprehensive advanced-level study of organizational behavior and management. Topics include a survey of the management functions of planning, organizing, and controlling; an introduction to individual and group behavior in organizations; an extensive study of motivation and leadership. Major behavioral theories are explored in detail. Practical applications are explored by the use of experiential exercises, case studies, and laboratory discussions. Other topics developed include decision-making, communication, responsibility, authority and accountability.

32-202 Naval Ships Systems I

Spring: 9 units

A detailed study of ship characteristics and types including ship design, hydrodynamic forces, stability, compartmentalization, propulsion, electrical and auxiliary systems, interior communications, ship control, and damage control. Included are basic concepts of the theory and design of steam, gas turbine, internal combustion, and nuclear propulsion. Shipboard safety and firefighting are also discussed.

32-212 Navigation

Spring: 9 units

An in-depth study of piloting and an introduction to celestial navigation theory. Students learn piloting skills including the use of charts, visual and electronic aids, and the theory and operation of magnetic and gyro compasses. Students develop practical skills in both piloting and celestial navigation. Other topics include tides, currents effects of wind and weather, plotting, use of navigation instruments, types and characteristics of electronic navigation systems, and the typical day's work in navigation. Also included is a study of the international and inland rules of the nautical road, relative motion, vector analysis theory, and relative motion problems.

32-300 Naval Laboratory

Fall and Spring: 3 units

Military drill, physical fitness, and leadership seminars.

32-302 Navigation and Naval Operations II

Spring: 9 units

A study of the international and inland rules of the nautical road, relative motion, vector analysis theory, relative motion problems, formation tactics, and ship employment. Also included is an introduction to naval operations and shipboard evolutions, vessel behavior and characteristics in maneuvering, applied aspects of ship handling, and afloat communications.

32-310 Evolution Of Warfare

Spring: 9 units

This course is to provide the student with a very basic understanding of the art and concepts of warfare from the beginning of recorded history to the present day. The intent of the curriculum is to familiarize the student with an understanding of the threads of continuity and the interrelations of political, strategic, operational, tactical, and technical levels of war from the past, while bringing into focus the application of these same principles and concepts to the battlefields of today and the future.

32-311 Naval Ship Systems I-Engineering

Fall: 9 units

A detailed study of ship characteristics and types including ship design, hydrodynamic forces, stability, compartmentalization, propulsion, electrical and auxiliary systems, interior communications, ship control, and damage control. Included are basic concepts of the theory and design of steam, gas turbine, internal combustion, and nuclear propulsion. Shipboard safety and firefighting are also discussed.

32-312 Naval Ship Systems II-Weapons

Spring: 9 units

This course outlines the theory and employment of weapons systems. The student explores the processes of detection, evaluation, threat analysis, weapon selection, delivery, guidance and explosives. Fire control systems and major weapon types are discussed, including capabilities and limitations. The physical aspects of radar and underwater sound are described in detail. The facets of command, control, and communications are explored as a means of weapons system integration.

32-400 Naval Laboratory

Fall and Spring: 3 units

Military drill, physical fitness, and leadership seminars.

32-401 Naval Ships Systems II

Fall: 9 units

This course outlines the theory and employment of weapons systems. The student explores the processes of detection, evaluation, threat analysis, weapon selection, delivery, guidance and explosives. Fire control systems and major weapon types are discussed, including capabilities and limitations. The physical aspects of radar and underwater sound are described in detail. The facets of command, control, and communications are explored as a means of weapons system integration.

32-402 Leadership and Ethics

Spring: 9 units

The study of naval junior officer responsibilities. The course exposes the student to a study of ethics, decision making and responsibility as well as counseling methods, military justice administration, naval human resources management, directives and correspondence, naval personnel administration, material management and maintenance and supply systems. This capstone course in the NROTC curriculum builds on and integrates the professional competencies developed in prior course work and professional training.

32-410 Amphibious Warfare

Fall: 9 units

A historical survey of the development of amphibious doctrine and the conduct of amphibious operations. Emphasis is placed on the evolution of amphibious warfare in the twentieth century, especially during World War II. Focus is applied to four main themes: political/strategic situation, sea-to-land transitions, tactics ashore, and development of amphibious technology. Present day potential and limitations on amphibious operations, including the rapid deployment force concept, are explored.

32-411 Naval Operations and Seamanship

Fall: 9 units

Designed as an introduction to naval operations and shipboard evolutions, vessel behavior and characteristics in maneuvering, applied aspects of ship handling, and afloat communications. This course builds upon the information presented in Navigation 32-212, Engineering 32-311, and Weapons Systems 32-312. An understanding of the nautical rules of the road, relative motion and vector analysis are utilized in discussion regarding the conduct of naval operation to include formation tactics and ship employment. The student will also be introduced to the various components of naval warfare and their role in sea control and power projection missions within naval and joint operations.

Philosophy Courses

80-100 Introduction to Philosophy

All Semesters: 9 units

In this introductory course we will explore three major areas of Philosophy: Ethics, Metaphysics, and Epistemology. Accordingly the course is divided into three sections. In each section we will read primary sources and discuss some of the main philosophic problems associated with that area. These will include: moral problems (Ethics), problems rising from the debates about free-will, personal identity or intelligence (Metaphysics), and inquiries about the scope and limits of human knowledge (Epistemology). We will then introduce some theories designed to solve such problems, and try to understand the strengths and weaknesses of these theories. We will apply different techniques and theories to issues that we might encounter in the real world. We will use class discussions, homeworks and papers to learn skills for evaluating arguments. These skills include: how to present a philosophic argument, what are the assumptions that justify it, what are its weaknesses and its strengths, whether such weaknesses can be resolved and, if they cannot be resolved, why.

80-101 Freshman Seminar: Cyberspace and Philosophy

Spring: 9 units

The advent of the computing power and communication tools (both personal and automated) now available on the Internet has had a significant impact on conversations and conclusions about many traditional subjects in philosophy. Topics impacted include: the nature of "intelligence," our status as separate individuals with a unique identities, the structure of human knowledge, the nature of certain human "rights," e.g., the rights to privacy or to ownership of the products of work, the values we place on social interactions and relationships, and what constitutes a "free marketplace of ideas." This seminar will explore living in and with the various features of the cyberspaces that now permeate and, in part, constitute our lives. Topics will include consciousness and intelligence (both human and machine), life in computer simulations (Are we living in one?), ethical issues created by or intensified in cyberspace, and the effect of cyberspace on living a good life. We will explore together the implications these new dimensions of human experience have on our understanding of the world and on our beliefs on how we choose to live our lives.

80-105 Freshman Seminar: Philosophy and The 100

Fall: 9 units

Bellamy: "Who we are and who we need to be to survive are two very different things." Philosophers often use thought experiments in order to examine fundamental philosophical questions, and the best thought experiments are often found in science fiction. In this course, we will examine a number of philosophical issues raised in the television show *The 100*, and possibly other science fiction stories, novels and movies. The idea is that science fiction most often revolves around people in extreme circumstances, and contemplating these circumstances is often the best way to learn about ourselves. And this is exactly what philosophy is: an investigation of the human condition. We will use the TV show's episodes as stepping stones for addressing questions such as the following: How should we live? Why behave morally? What makes our lives valuable? Are humans ultimately free?"

80-110 Nature of Mathematical Reasoning

Intermittent: 9 units

This course focuses on understanding the principles and problems at the root of mathematical reasoning; it is not a course on any specific mathematical theory, like linear algebra or topology. We will explore the foundations of mathematics, both in terms of their historical origin and their modern purpose as a base for the study of mathematics. Then we will see how problems which seem to have no intuitive solution look simple after being put in the right mathematical form, but also consider the limitations this type of approach. We will treat such issues as they arise both in applied fields (policy decision-making, physics, computer science) and as more recreational, speculative and abstract (Conway's game of life, the works of Escher, music). The course is aimed for students at the freshman and sophomore level who do not necessarily intend to pursue a mathematically intense major.

80-115 Freshman Seminar: Measurement and Methodology

Spring: 9 units

This is intended as an introduction to the theory of measurement. How are units chosen? Under what conditions do qualitative relationships determine quantitative ones? We shall investigate theories of extensive measurement, with and without error. Applications will be taken from the natural and social sciences. Prerequisites: None specifically; however, students should have background in elementary logic and be comfortable with taking mathematical approaches to conceptual problems.

80-130 Introduction to Ethics

Intermittent: 9 units

As human beings, we frequently grapple with difficult moral questions. How ought I treat my friends and peers? What kinds of policies should a government adopt? When, if ever, can we justify harm? These are the kinds of questions we will consider as we survey the most prominent, contemporary ethical theories. Along the way, we will consider the implications of those theories for real world ethical issues, including capital punishment, pornography, and universalized healthcare.

80-135 Introduction to Political Philosophy

Intermittent: 9 units

What obligation do we have, as citizens, to our government or community? What obligation does our government have to us? Philosophical debates arise in public life all the time. We expect that the government and others around us respect certain rights we have, we acknowledge some communal obligations when pay our taxes or establish welfare programs, and we participate in democratic processes. But what are we talking about, when we speak of "rights"? Or "justice"? Why do we assume that democracy is good? The ideas we invoke along the way — justice, equality, rights, democracy, progress — these are the subjects of political philosophy. In this seminar we will interrogate some of these ideas by examining traditions in Western political thought and the challenges to some of these traditions from more contemporary authors. We will begin by reading some classical texts in the social contract tradition, and dissents from anarchist, communist, and feminist thinkers. We will think about whether individuals do in fact or should have "rights." We will read philosophical reflections on political revolutions and political change. We will investigate justifications for democratic government. Finally, we will turn out attention to some of the most pressing challenges of our age: multiculturalism, identity politics, and justice as it relates to race and gender.

80-136 Social Structure, Public Policy & Ethics

Intermittent: 9 units

The course will consider ethical questions that arise regarding social structure and public policy's impact on both people and the environment. It will consider the role of political institutions (and, sometimes, individuals) in dealing with some of the greatest challenges facing our generation: World poverty, environmental problems, and globalization. Some of the questions we will consider include: Are developed countries like ours obligated to ameliorate poverty by providing foreign aid, are they obligated to prevent environmental problems, and is globalization and free trade in particular a good idea? The course uses theory, case studies, and empirical evidence to consider these questions from a few different moral and political perspectives. We will extract some economic principles and rational dilemmas from examining these issues and pay attention to how legal and empirical considerations interact with ethical considerations.

80-150 Nature of Reason

Intermittent: 9 units

This course offers an intellectual history of philosophical views regarding the nature of human reasoning in mathematics and the sciences, from ancient to modern times. The first part of the course traces the search for deductive methods for obtaining certain knowledge, starting with Aristotle and Euclid, and continuing through the Middle Ages and late Renaissance thought, to the work of Boole and Frege in the nineteenth century. The second part of the course considers the history of skepticism about empirical knowledge, covering Plato, Sextus Empiricus, Descartes, Pascal, and Hume, along with replies to skepticism in the works of Bayes and Kant. The third part of the course discusses theories of the nature of mind, culminating in the computational conception of mind that underlies contemporary cognitive science.

80-180 Nature of Language

Fall and Spring: 9 units

Language is used to talk about the world or to describe it, but how do we go about describing language itself? Linguistics is the name given to the science of language, whose task it is to give such a description. The discipline of linguistics has developed novel tools for describing and analyzing language over the last two hundred years and in this course we learn what these tools are and practice applying them. Sub-areas of linguistics which we study include phonetics (the study of speech sounds), phonology (the study of sound systems), morphology (the study of parts of words), and syntax (the study of combinations of words). Beyond this, we look at changes in language over time, and we consider the puzzle of linguistic meaning. The methods of linguistics are useful in the study of particular languages and in the study of language generally, so this course is useful for students of foreign languages as well as those interested in going on to study language acquisition, psycholinguistics, sociolinguistics, philosophy of language, and computer modeling of language.

80-195 Research Training

Fall and Spring: 9 units

This course is part of a set of 100-level courses offered by H&SS departments as independent studies for students in the College. In general, these courses are designed to give students some real research experience through work on a faculty project or lab in ways that might stimulate and nurture subsequent interest in research participation. Faculty and students devise a personal and regularized meeting and task schedule. Each Research Training course is worth 9 units, which generally means a minimum for students of about 9 work-hours per week. These courses are offered only as electives; i.e., they cannot be applied toward a college or major requirement, although the units do count toward graduation as elective units. Additional details (including a roster and descriptions of Research Training Courses available in any given semester) are available in the H&SS Academic Advisory Center. For H&SS students only; only for second-semester freshmen, or first- or second-semester sophomores; minimum cumulative QPA of 3.0 (at the time of registration) required for approved entry; additional prerequisites (e.g., language proficiency) may arise out of the particular demands of the research project in question.

80-201 Epistemology

Intermittent: 9 units

Epistemology, one of the cornerstones of philosophy since ancient times, concerns the relationships between belief, truth, and knowledge. This course will explore fundamental issues in epistemology, such as the analysis of the concept of knowledge, epistemic justification and scientific method, a priori knowledge, theories of truth, skepticism, reliabilism, and coherentism. Both classic texts and contemporary journal articles will be discussed. There are no prerequisites, but students with some philosophical sophistication and/or formal ability will be more comfortable with the material.

80-208 Critical Thinking

Intermittent: 9 units

This course is an introduction to practical reasoning. The course will contain an elementary introduction to concepts important for reasoning and decision making, such as validity, probability, and utilities. Students will extensively practice critically analyzing and evaluating a wide variety of arguments found in newspapers, magazines, and elementary accounts of scientific reasoning. In order to help students develop the skills to analyze and evaluate arguments, the course will introduce several software packages recently developed at CMU that help students diagram arguments and causal reasoning; these packages have been shown to improve students' critical reasoning skills. In addition, students will learn about a wide variety of statistical, logical, psychological, and causal fallacies that are used to mislead people.

80-210 Logic and Proofs

All Semesters: 9 units

This web-based course introduces students to central issues in logic and develops their ability for constructing and refuting arguments. It addresses the question: How can one analyze the structure of rational discourse or, more specifically, the logical structure of argumentation? An answer to this question requires: (i) uncovering the logical form of statements; (ii) defining the correctness of logical steps; (iii) formulating inference rules for the logical forms; (iv) designing strategies for argumentation with the inference rules. The course takes these steps for both sentential and quantificational logic. Presentation: The material is presented on-line, though some exercises must be done with pen and paper. Additional reading of historical and philosophical character complements the systematic on-line presentation. Weekly small discussion meetings with collaborative reviews, substantive discussions and critical reflections supplement the on-line material.

80-211 Logic and Mathematical Inquiry

Intermittent: 9 units

Since ancient times, mathematical arguments have served as a paradigm for rational inquiry. This course studies the structure of such arguments and their applications. We will study foundational mathematical concepts and informal proofs, as they appear in everyday mathematics. At the same time, in parallel, we will study mathematical logic, which provides formal symbolic languages for mathematics. The course will make use of a computational "proof assistant" to develop fully rigorous, machine-checked proofs. This course prepares students to take the 310-311 series on the fundamental (in)completeness and (un)decidability theorems of modern logic.

80-212 Arguments and Logical Analysis

Intermittent: 9 units

Are there rational methods that can further our knowledge? The notion of rational inquiry presupposes that there are appropriate methods for the pursuit of knowledge. In this course, we will investigate the means by which a successful argument justifies its conclusion, as well as various subtle ways in which other arguments fail. In the course of our inquiry, we will take a historically informed approach to studying logic and argumentative fallacies. We will also discover that these tools are useful for constructing and analyzing arguments in all disciplines from philosophy and history to psychology and physics. Our primary goal is to learn to use these tools to make our thinking and writing clearer, more precise, and more critical. To that end, our coursework will consist in homework and exams on topics in logic, as well as essays on a wide variety of topics. This course is intended for students from any discipline who would like to improve their writing and critical thinking skills.

80-214 Computing, AI, and Philosophy

Summer: 9 units

The aim of the course is to give an interdisciplinary introduction to computation, artificial intelligence, and philosophical questions regarding them. It will also include historical and sociological issues concerning these topics as well as their representation in the arts. The course does not require a background in mathematics, computer science or philosophy.

80-220 Philosophy of Science

Intermittent: 9 units

In this course, we will examine some historical case studies (e.g., the Copernican revolution in astronomy) against which we will assess views pertaining to the significance, justification, and production of scientific knowledge. For example, should scientific theories be understood literally or as computational devices for deriving new predictions? How can universal conclusions ever be justified by a finite data set? Does explanation contribute to a theory's confirmation by the evidence? Does science aim to find the truth? Is probability in the world or only in our minds? Is explanation a matter of finding causes or are causes whatever it is that explains? Is scientific rationality objective or culture-relative?

80-221 Philosophy of Social Science

Spring: 9 units

This course will explore various philosophical issues germane to social science. The central question of the course asks whether we can use traditional scientific tools to understand social phenomena, e.g. wars and religions, in the same way that we use them to understand natural phenomena, e.g. gases, lasers and planetary orbits. Some of the more specific questions we address: Because humans possess free will and act with intentions while light rays and planets in motion do not, are we forced to use logically different species of explanations in the two cases? How can we explain social institutions that depend upon cooperation? Whereas natural scientists actively conduct experiments, social scientists can often only collect statistical data. Does this difference prevent social scientists from inferring causal relations? Is our understanding of social phenomena always value laden?

80-222 Measurement and Methodology

Spring: 9 units

This is intended as an introduction to the theory of measurement. How are units chosen? Under what conditions do qualitative relationships determine quantitative ones? We shall investigate theories of extensive measurement, with and without error. Applications will be taken from the natural and social sciences. Prerequisites: None specifically; however, students should have background in elementary logic and be comfortable with taking mathematical approaches to conceptual problems.

80-226 Revolutions in Science

Intermittent: 9 units

Contemporary science emerged in the 17th century from a series of dramatic innovations in theory and method that has come to be called the Scientific Revolution. Since then, science has been punctuated by repeated 'revolutions' in which scientists have been forced to select among dramatically different frameworks for explaining the world: is the Earth or the sun at the center of the solar system? Do kinds of organisms develop from other kinds, or is each created independently? Is matter infinitely divisible or are all things made of atoms in a void? The way scientists choose one framework over another can tell us something about the nature of science. In this course, we will focus on episodes of scientific change to gain insight into a range of questions: Is scientific change governed by a single method or does each new revolution involve the invention of a new scientific method? How do scientists argue for the existence of unobservable processes, properties, or objects like atoms? In what way do these arguments differ from those of their ancient predecessors? What makes them compelling? We'll begin our investigation by examining the overthrow of ancient Greek astronomy and physics by Galileo, Kepler, and Newton. We will then turn to a number of subsequent revolutions in other areas of science such as chemistry, geology, and evolutionary biology. Students will work with original texts by Galileo, Newton, Darwin, and others.

80-230 Ethical Theory

Spring: 9 units

Every day, even in very subtle ways, we make judgments of value that shape our lives and our conduct. This course will examine four influential attempts at providing a systematic account of the source and nature of moral value, its relationship to other kinds of value, and the practical implications of different answers to these questions. This focus on the fundamental structure of moral value will frequently engage topics such as the nature of the good, subjectivist and objectivist accounts of value, forms of moral naturalism versus attempts at moral constructivism, and will draw on historical as well as more contemporary sources. Particular attention will be paid to articulating the specific sources of disagreement that distinguish competing moral theories in order to facilitate our ability to adjudicate between them on a reasoned basis.

80-235 Political Philosophy

Intermittent: 9 units

At the heart of political philosophy lie fundamental questions such as: What constitutes a just society? How, and under what circumstances do individuals incur special political obligations to a particular state? What are the limits of the legitimate authority of the state and how are they defined? This course provides a systematic investigation of the way such questions are answered by dominant schools of liberal political theory, such as the social contract tradition, utilitarianism and libertarianism. Because the liberal political tradition is also strongly egalitarian in nature, the course will examine different conceptions of political equality and conflicting views about the respects in which community members may have a just claim to equal treatment. Readings are drawn from classic works by authors such as Hobbes, Locke, Kant, and Mill, and from the works of contemporary theorists like Rawls, Nozick and others.

80-241 Ethical Judgments in Professional Life

Intermittent: 9 units

This is a multimedia, hybrid course that examines the numerous ethical issues, problems and dilemmas that confront professionals in such areas as medicine, law, engineering, the media, government and the natural and social sciences. As a hybrid course, it includes educational materials in video streaming format, an audio CD, an electronic discussion board and web-based "guided inquiries" that students navigate and complete. Topics discussed include: Responsibility in the professions, obligations to clients, conflicts of interest, Whistleblowing, codes of ethics and ethics in engineering, medicine, law, media, computer science and business among others. This course meets one day a week and employs a case study discussion format during class.

80-242 Conflict and Dispute Resolution

Intermittent: 9 units

Conflict is an intractable feature of human life, whether occurring between family members, friends, coworkers, political organizations, nations, and even within oneself. You must then be prepared to negotiate with others to get your job done, to advance your career, and even to maintain meaningful personal relationships with your family and friends. The purpose of this course is to help prepare you for these negotiations. In particular, in this course, you will reflect on your current approaches to conflict, study the nature of conflict and why it tends to escalate, and develop your own skills for principled negotiation. Throughout the course you will also participate in negotiation simulations exercising your powers of communication and persuasion while practicing conflict resolution tactics. My goal is that you finish this course a more reflective and effective negotiator, better prepared to handle the conflicts you will inevitably face.

80-243 Ethics of Leadership

Intermittent: 9 units

From business operations to international affairs, leadership concerns the use of power or influence to coordinate a group towards common purpose. However, leadership also requires the acceptance of responsibilities not shared with the other group's members. Given their distinctive role and responsibilities, leaders must be prepared to face a unique host of moral problems and dilemmas. In this course, we will pursue the question of what makes a morally good leader, as opposed to a merely effective one. To that end, we will critically examine various competing theories of leadership while considering the moral challenges that arise when power, self-interest, justice, and the collective good collide.

80-244 Environmental Ethics

Intermittent: 9 units

The aim of the course is to provide students with an introduction to environmental ethics. One aspect of environmental ethics is the study of values underlying human relations to the natural environment. In particular, we are interested in issues that arise when these values conflict. This course begins with a discussion of our current environmental crises, and different approaches to solving these crises. Many of these solutions, however, depend on particular kinds of knowledge, particularly scientific knowledge, about our environment. Thus, another important aspect of environmental ethics is determining what we do, and what we can, know. To address these issues, we will explore some problems in philosophy of science, with special emphasis on the various eco-sciences.

80-245 Medical Ethics

Fall: 9 units

This course provides an introduction to core ethical issues in health care, medical research, and public policy. Topics include: the moral responsibilities of health care providers to patients and various third parties such as the government or insurance companies, the status of health as a social good, and questions of individual liberty and social responsibility at the ends of life including issues such as abortion, physician assisted suicide, and the definition of death. We will also examine specific ethical issues in the conduct of medical research and look at the impact of technological innovation on our notions of health, disease, life, death, and the family. If time permits, we may also discuss issues related to genetics and cloning. While the course engages such substantive ethical issues it also attempts to sharpen students' skills in practical reasoning through argument analysis, analogical reasoning, and the application of theory and principles to particular cases.

80-246 Moral Psychology

Intermittent: 9 units

Moral psychology is the study of how we think about morality, make moral judgments, and behave in moral situations. This has important implications for how we should think about morality, make moral judgments, and behave in moral situations. In this course we will examine empirical research on moral thinking and behavior by psychologists, neuroscientists, economists, and philosophers and discuss the implications this research has for issues in ethics. We will address questions such as: What motivates our moral behavior? Do we ever act altruistically or do we only do the right thing because it's somehow in our own interest? Is it even possible to tell what people's real motivations are? How do we make moral judgments and decisions? What roles do reason, intuition, and emotion play in our moral judgments? What role should they play? What role should a person's beliefs, desires, and intentions play in our judgments of how blameworthy the person is or of how much punishment he or she deserves? What role should the outcomes of the person's actions play in our judgments of him or her? Should we hold people responsible for things that are not entirely under their control?

80-247 Ethics and Global Economics

Intermittent: 9 units

The course considers the secret lives of every day things — like food, water, and oil. It suggests that it is by understanding these things that we can best address some of the greatest challenges facing our generation including world poverty and environmental problems. After a short introduction to arguments and ethical theory, the course considers how basic commodities like oil, water, and bananas have shaped and will continue to shape human and natural history. The course then outlines some of the environmental and social implications of the ways we create, use, and trade basic commodities. Finally, it considers prospects for dealing with some of the challenges posed by our past, present, and future use of these commodities. Global Economics and Ethics lays the groundwork for dealing with some of the most important issues facing our generation.

80-248 Engineering Ethics

Fall: 9 units

This course provides an introduction to core ethical issues in engineering research and practice. Topics include: the moral responsibilities of engineers to clients and various third parties such as the government or insurance companies, conflicts of interest, whistleblowing, codes of ethics, and the status of engineering projects as social goods. While the course engages such substantive ethical issues it also attempts to sharpen students' skills in practical reasoning through argument analysis, analogical reasoning, and the application of theory and principles to particular cases. This course meets two days a week and employs a case study discussion format during class.

80-250 Ancient Philosophy

Intermittent: 9 units

This course will cover Ancient Greek philosophy from the pre-Socratics to the later Hellenistic writers. We will prepare the background for Socrates and Plato by tracing the various historical and intellectual movements that led up to and through the flourishing and downfall of Periclean Athens. A study of Socrates (as represented in Aristophanes' comedy and Plato's early dialogues) will lead to an in-depth reading of Plato's *Gorgias*, *Symposium* and sections of the *Republic*. We will approach Aristotle through his 'practical philosophy' as presented in the *Nicomachean Ethics*. The final sections will discuss the Epicurean, Skeptic, and Stoic movements as well as the work of Cicero. Excerpts from other works of Plato and Aristotle as well as Martha Nussbaum's recent work on Aristotle and Hellenistic philosophy will accompany selected parts of the course.

80-251 Modern Philosophy

Intermittent: 9 units

Descartes' project to doubt all received knowledge and begin from scratch marked the beginning of an intellectual upheaval, helping to launch what is now called the Modern period of philosophical thought; the Western world is today the heir of modernism. Locke, Leibniz, Hume, and Kant are several of the most important figures of this period. We will examine works of these thinkers, exploring both the new sorts of questions that these philosophers raised and their new methods of doing philosophy, which together mark a fundamental break with the traditions that preceded them. We will devote special attention to the new theories of knowledge they proposed and to their works in ethics and political philosophy. The philosophical revolution of the 17th and 18th centuries occurred during a time of great scientific progress and political upheaval in Europe; as part of our course we will consider the relation of certain of these developments to the new questions and methods of the modern philosophers and to their works in ethics and political philosophy.

80-252 Kant

Intermittent: 9 units

Immanuel Kant's 'Critical philosophy' may be seen as the result of his attempts to determine the sources of human knowledge, and to find metaphysical foundations for Newton's mechanics. This course will involve readings in Kant's *Critique of Pure Reason* and other texts. Emphasis will be placed on understanding Kant's thought in the context of contemporary intellectual developments and on his theory of human cognition.

80-253 Continental Philosophy

Intermittent: 9 units

This course provides students with an overview of key historical and philosophical movements in European Philosophy. The cultural and historical background for 20th Century Continental Philosophy covers Descartes, Kant, Kierkegaard, and Nietzsche (Hegel and Marx are also options). Early to mid-20th Century Continental Philosophy covers the central tenets of phenomenology and existentialism (e.g., intentionality, Being-in-the-World, Bad Faith). This part will involve selections from the works of, for example, Husserl, Heidegger, Sartre and Merleau-Ponty. Finally, cultural and philosophical trends such as Structuralism, Hermeneutics and Post-modernism (e.g., Derrida, Foucault, Lyotard and Habermas) will be addressed.

80-254 Analytic Philosophy

Intermittent: 9 units

This course examines the revolutionary impact of philosophy at the turn of the 20th century on contemporary thought and progress. By the 1920s some scientists and philosophers became hopeful that the end of the long tradition of philosophical deadlock was finally within reach. Buoyed in particular by Einstein's theory of relativity and the invention of modern logic, they created a new kind of philosophy with the goal of applying logical and empirical methods to philosophical problems. This new approach led to new puzzles and paradoxes, along with a focus on the age old question of what can be known and what is meaningful. The modern fields of linguistics, cognitive science, and information and computer sciences all owe a debt to these sources, as does of course contemporary philosophy. Our quest will be to understand both what authors like Frege, Russell, and the Vienna Circle were up to in the first place, and how their work contributed to the world we live in today.

80-255 Pragmatism

Intermittent: 9 units

American Pragmatism represents an energetic attempt to bridge the divergent cultures of science and the humanities. The movement's founder, C.S. Peirce, was trained in chemistry and worked as a physicist, but he was also deeply concerned with the contemporary philosophical portrayal of science, which distinguished sharply between theoretical knowledge and practice. Peirce responded by constructing a comprehensive philosophy emphasizing the scientific importance of community, fallibility, and action. Pragmatism was also developed and vigorously popularized by William James, who aspired to be a painter and ended up as an acknowledged founder of modern empirical psychology. James extended Peirce's position by defending the role of values in even the purest of empirical sciences. John Dewey, who is also well-known for his role in education, interpreted science as an evolving social system and developed a theory of aesthetics based on what we now call the psychology of problem solving. The pragmatists made and continue to make lasting contributions to modern statistics, logic, and social science and their emphases on community, fallibility, action, and value in science are still of primary importance in philosophy and in the ongoing dialogue between the scientific and humanistic cultures.

80-256 Modern Moral Philosophy

Intermittent: 9 units

This course will follow moral theory through the modern era (roughly 1600-1900), with special emphasis on the works of Hobbes, Hume, and Kant, as well as the development of utilitarianism. Since moral theorizing was only one part of these thinkers' larger systems of philosophy, it cannot be fully separated from questions of metaphysics and epistemology (e.g. free will, determinism, materialism, etc.), and we'll spend some time situating their ethical thought within their larger projects. In doing so, we'll also examine these theories within the context of the rapidly changing social, political, and scientific landscape of the modern period.

80-257 Nietzsche

Intermittent: 9 units

During his life in the late 19th-century, Friedrich Nietzsche was a relatively obscure German philosopher. Since his death, however, he has become deeply influential and well-known, and was a source of inspiration for many important 20th-century thinkers. Despite this popularity, Nietzsche's philosophy remains relatively mysterious, and often misunderstood. Much of his writing consisted of aphorisms, rather than more traditional prose and arguments, and many of his positions seem to contradict one another. This course will cover a broad range of Nietzsche's writings, focusing on such central concepts as the will to power, eternal recurrence, and the oft-misunderstood *Übermensch* ("overman"). Throughout, we will focus on developing a consistent interpretation of an enigmatic philosopher whose views have been mischaracterized and misappropriated throughout the past century.

80-258 Hume

Intermittent: 9 units

This course will investigate the philosophy of David Hume. We will focus on his philosophical thought expressed in the book *A Treatise of Human Nature*. Hume was an influential philosopher who wrote on many issues ranging from skepticism, to ethics, to the philosophy of science, and his views continue to be influential today. In this course we will attempt to understand Hume's philosophy on all of these subjects both to better understand his contribution to the philosophy of his day, but also to see what his arguments can contribute to contemporary thought.

80-261 Empiricism and Rationalism

Intermittent: 9 units

A central issue in Western philosophy has been whether reason or experience (or some of both?) lies at the foundation of human knowledge, and the 17th and 18th centuries are a defining period of European history because they contribute the basic model of science and the ideals of intellectual and political enlightenment that are still dominant today. Specifically, we will focus on the problems encountered in trying to give an adequate account of the nature of the external world, the structure of our minds, and the nature and limitations of knowledge in the thought of Descartes, Locke, Leibniz, Berkeley, and Hume. The course has two main goals: (1) to study the metaphysical and epistemological theories of selected philosophers, paying close attention to the arguments offered on behalf of often very strange positions, and (2) to help you improve your analytical and critical skills, including, for example, extracting and evaluating philosophical arguments.

80-262 Introduction to the Philosophy of Bertrand Russell

Intermittent: 9 units

Near the start of the 20th Century, Bertrand Russell helped to create what today we call "Analytic Philosophy." We will study Russell's contributions to this important approach to Philosophy by using his 1912 book, "The Problems of Philosophy" as a springboard to other readings. The issues we'll cover include several specific challenges in the Theory of Knowledge and Perception. For example, What is the difference between appearance and reality, and can we tell? Also, we'll consider issues that stem from reflecting on our thinking. For example, What constitutes a philosophical question?

80-264 William James and Philosophical Psychology

Intermittent: 9 units

This course will be devoted to the reading and discussion of William James' "Principles of Psychology", including its relevance to foundational questions about current research. Though first published in 1891, the foundational issues addressed in this landmark work have not lost their relevance; it is often said that this work set the agendas for much of the research subsequently carried out in psychology. This course should appeal to anyone interested in philosophy of mind, philosophy of psychology, and philosophy of science.

80-270 Philosophy of Mind

Intermittent: 9 units

The mind poses one of the greatest challenges to understanding how the world works. What is a mind? What is consciousness? What is sensing? What is agency? How are these facets of subjectivity related to the objective, physical world? In this course, we tackle these challenging questions with a philosophical approach that highlights analysis and argument, though we will also bring in relevant empirical understanding of the mind and brain to enrich our discussion (a complementary course, Philosophy and Psychology, is taught in alternate years where the empirical issues are the focus with enrichment from philosophy). A central practical aim of this course is to promote development of analytical skills through practice engaging with arguments.

80-271 Philosophy and Psychology

Intermittent: 9 units

This course has two parts. First, we will look at basic concepts used in psychology (and cognitive science broadly) through the lens of philosophy including: representation, computation, information, explanation, modularity, attention, automaticity and control. Having some concrete proposals about these ideas will allow us to formulate psychological claims more concretely. Second, we will reverse course and look at traditional philosophical problems through the lens of psychology focusing on three topics: consciousness, agency, and perception. Specifically: what is consciousness, what is it to be an agent, what is it to perceive?

80-275 Metaphysics

Intermittent: 9 units

The topical agenda of this course will vary. Typical topics include the problem of personal identity, the nature of human freedom, the nature of the self, the nature of reality and being, the nature of causality, and the question of whether solutions to such problems can be given. Classical as well as contemporary philosophic texts will be studied. For Spring 2011: Issues we will consider, in no particular order, include: Do properties exist? Why should you think there is an external world? What is a number? Why should you think other people have mental states? What are natural kinds? What constitutes the identity of things through time? What constitutes the identity of persons through time? What does determinism mean? Is there freedom of the will? What is possibility? What is necessity? Are there other possible worlds? When does one event cause another, and what does that mean? What could a deity be, and should you think there is one?

80-276 Philosophy of Religion

Intermittent: 9 units

In order to expand our ideas about what religion could be, the course begins with a brief cross-cultural review of some major religious traditions around the world. Then we turn to some more traditional arguments for and against theism, including the ontological, cosmological, and design arguments, the argument from religious experience, the argument from miracles and historical testimony, and the problem of evil. We will also consider whether morality ultimately depends on God's sanctions and (yes, here it is at Carnegie Mellon) whether life would be meaningless if God did not exist.

80-280 Linguistic Analysis

Intermittent: 9 units

At one level, language is constituted by nothing but sounds, or marks on paper. How can such physical objects be used to create or transmit meaning? The answer assumed in this course is that objects with specific physical features are assigned symbolic or linguistic values on the basis of those features. By the juxtaposition of such objects (phonemes or graphemes), larger symbolic objects are created (morphemes). Morphemes have the special property that they can be associated in a consistent way with meanings. In a progressive fashion, words are built from morphemes, phrases from words, and sentences from phrases. Sentences have different moods, and these moods correspond to their function with respect to the encoding and transmission of information. Indicative sentences carry information, interrogative sentences request information, imperative sentences demand action, conditional and modal sentences present alternative possibilities, and so on. The goal of this course is to investigate the structure of the linguistic entities by which these communicative functions are realized. Building on material taught in Nature of Language, we look in detail at the morphology and syntax of human languages, paying special attention to cross-linguistic variety.

Prerequisite: 80-180

80-281 Language and Thought

Intermittent: 9 units

We use language to communicate. Communication seems to involve something like the transfer of ideas or thoughts from one individual to another. In this course, we'll try to understand how that works, given that we cannot in fact take our thoughts out of our heads and show them to someone else. We'll explore different views on the relationship between thought and meaning, and different views about how language succeeds in communicating thoughts and ideas. We'll explore the idea of a language of thought, and ask whether the language we speak influences our thought. At the same time, we will want to understand how it is that language hooks up to the world, enabling us to talk not only about what we think, but also about the way things actually are. We'll look at the role of inference in language understanding, and at the nature of non-literal communication, in particular metaphor. The course will be based on readings drawn from philosophy, linguistics and psychology. Students in the course should be prepared for extensive reading, writing and peer discussion assignments.

80-282 Phonetics and Phonology I

Fall: 9 units

This course aims to provide students with practical tools for the study of speech sounds. The acoustic properties of sounds are examined using spectrograms and other devices, with emphasis on vowels and sonorant consonants. Following this, basic phonological notions are covered, tracing their development in the twentieth century up through optimality theory. In optimality theory, contrast and allophonic variation are explained in terms of an input-output device which selects the most harmonic candidate still faithful to phonemes in the input. The course should be relevant not only to linguistics students, but to students of language generally, with applications to sociolinguistics, child language development, speech recognition technologies, and the study of foreign languages.

Prerequisite: 80-180

80-283 Syntax and Discourse

Intermittent: 9 units

In English and many other languages, it is possible to express the same content in several different, but closely related ways. For example, the following sentences all seem to have the same content: "John saw Mary"; "Mary was seen by John"; "It was John who saw Mary"; "John, he saw Mary". Yet the sentences are not interchangeable in discourse. Sentences can also be differentiated by intonation: in the sentence John saw Mary, any of the three words can be emphasized, and these changes in emphasis have consequences for what the sentence expresses. In this course, we will develop the view that these syntactic and intonational manipulations carry information about whether information is being presented as new or old, novel or familiar, foregrounded or backgrounded, and about how the content presented is connected to ongoing discourse. In the course, students will learn the methodology for exploring the discourse functions of different constructions, and skills and concepts to use in describing these functions. At the same time, we will need to fully grasp the syntactic properties of the sentence-types in question. Syntactic analyses will build on the syntax developed in 80-180 Nature of Language and additional courses covering syntax (depending on the experience of the participants).
Prerequisite: 80-180

80-284 Invented Languages

Intermittent: 9 units

Ordinary human languages are not designed or invented, but instead grow organically within human communities. Nevertheless, over the centuries, many have succumbed to the temptation to try to design languages of their own. Some have tried to improve upon the perceived inadequacies of available natural languages (e.g., Zamenhof's Esperanto and Brown's Loglan), while others have sought to imitate nature, creating their own languages for artistic purposes (e.g., Tolkien's Elvish languages, Okrand's Klingon, and Peterson's Dothraki and Valyrian). In this course, we will explore the linguistic considerations involved in language invention, along with the linguistic lessons of the history of language construction attempts, with a particular emphasis on applying these insights to our own invented languages. Activities will include the development of one or more major components of the grammar of a new invented language, along with problem sets that provide general linguistic background and more limited exercises in language design. This course does not assume any background in linguistics, and is intended to accommodate both newcomers and advanced students.

80-285 Natural Language Syntax

Fall: 9 units

This course is intended to provide an introduction to the methods of syntactic analysis, and to some major themes of contemporary syntactic theory, following up on syntactic concepts introduced in 80180, Nature of Language. A primary theme of the course is the structural constituency of a sentence, and the course will address some of the following questions. What are syntactic constituents? Do all aspects of syntax manipulate the same kinds of structural units, or do different grammatical processes rest on incompatible notions of constituency? How do other syntactic relations connect with constituent structure? To the extent that there is mismatch between different notions of syntactic structure, how can it be reconciled within a theory of grammar? These questions are engaged in through the diagnostics and techniques of modern syntactic analysis and argumentation. Those tools will allow us to explore the striking ways in which syntactic theory unifies diverse grammatical phenomena in terms of a common notion of phrase structure. The course complements 80280, Linguistic Analysis, building on but not presupposing syntactic analyses developed in that class.

80-286 Words and Word Formation: Introduction to Morphology

Intermittent: 9 units

How many words do you know? Is 'gonna' one word or two? How many meanings does 'unlockable' have? If someone can be 'inept', why can't they be 'ept'? In this course we study the linguistics of words and word formation, known as morphology. We begin by asking what a word is, about the internal structure of words, and how new words are formed. Throughout, we will consider these questions from a cross-linguistic perspective, looking at morphological data from a wide range of languages. We will also consider how morphology interacts with other subfields of linguistics, including phonology, syntax and semantics. Finally, we will survey morphological questions from the perspectives of language acquisition, psychology, and cognitive science.
Prerequisite: 80-180

80-287 Historical and Comparative Linguistics

Intermittent: 9 units

This course provides an introduction to the study of language change. The languages we speak are always changing: over time, these small changes can accumulate into more significant ones, making it possible for very different languages to derive from a common linguistic ancestor. These observations immediately raise a number of questions. Which kinds of changes occur in the history of human languages? How can linguistic theory help us to make sense of these changes? What can we infer about the historical relationships between languages, and about unattested ancestors of known languages? In this course, we will explore techniques for addressing these questions, learning about some major themes and tendencies in sound change, grammatical change, and semantic change.

80-292 Learning Science Principles

Spring: 6 units

The ability to learn - that is, to change and adapt to one's environment - is one of the hallmarks of intelligence, whether in humans, animals, or machines. In this course, we will examine the nature, components, and significance of learning in many different manifestations, with a particular focus on the fundamental concepts that underlie the ways in which we understand the concept of learning in different disciplines. This course will thus focus more on concepts and foundations, rather than technical aspects of learning, whether mathematical, experimental, or computational. This course will be almost entirely project-based: you will work in groups (with students from different backgrounds) to identify opportunities for learning media, and then develop designs that appropriately address those opportunities. In the course of developing these media designs, you will learn, and come to understand, concepts and principles of learning from different disciplines. The emphasis throughout will be on careful conceptualization, description, and design of the learning through and about media.
Prerequisites: 15-104 or 15-112 or 62-150
Corequisite: 05-292

80-305 Rational Choice

Intermittent: 9 units

This course is an introduction to formal models of choice and decision-making. We begin by examining choice under certainty, developing both qualitative and quantitative models of preference. We then expand our analysis to take into account uncertainty: we examine the von Neumann-Morgenstern theory of expected utility, the Anscombe-Aumann account, and Savage's classic axioms. Empirical challenges to models are emphasized throughout, in response to which we will consider a variety of alternative representations of uncertainty (e.g., Dempster-Shafer belief functions, non-unique probability measures) and preference (e.g., framing effects, prospect theory).

80-310 Formal Logic

Fall: 9 units

Among the most significant developments in modern logic is the formal analysis of the notions of provability and logical consequence for the logic of relations and quantification, known as first-order logic. These notions are related by the soundness and completeness theorems: a logical formula is provable if and only if it is true under every interpretation. This course provides a formal specification of the syntax and semantics of first-order logic and then proves the soundness and completeness theorems. Other topics may include: basic model theory, intuitionistic, modal, and higher-order logics.
Prerequisites: 80-211 or 15-251 or 21-127 or 80-210 or 80-212

80-311 Undecidability and Incompleteness

Spring: 9 units

U&I focuses on two logical problems: the undecidability of predicate logic (established by Church and Turing) and the incompleteness of formal theories (discovered by Gödel for theories that contain a modicum of set or number theory). The solutions of these problems require a rigorous concept of computability that is fundamental for computer science as well as cognitive science. We first discuss predicate logic and strategic ways of constructing proofs. That is followed by the formal development of elementary set theory and the proof of the incompleteness theorems for that theory. Then, the concept of Turing machine computation is introduced and shown to be equivalent to the concept of a recursive function. That provides the mathematical tools for establishing the results mentioned above. The mathematical and computational notions and results are among the most significant contributions of logic, not just to the solution of internal logical questions and to the foundations of computer science, but also to the beginnings of a deeper understanding of the human mind and mental processes. In addition to the mathematical developments, we will discuss historical and philosophical aspects of the subject.
Prerequisites: 80-210 or 80-211 or 21-300 or 80-310 or 15-251

80-312 Philosophy of Mathematics

Intermittent: 9 units

The 20th century witnessed remarkable and novel developments of mathematics - with deep roots in the 19th century. The beginnings of these developments were beset with foundational problems and provoked a variety of programmatic responses: logicism, intuitionism, and finitism. For a deeper study of basic issues, we review a part of classical Greek mathematics (the theory of proportions) that is closely connected to the foundations of analysis in the 19th century. We analyze set theoretic and constructive approaches, and discuss fundamental metamathematical results and their philosophical implications. A "reductive structuralist" position will finally provide a perspective for understanding the abstract character of mathematics as well as its usefulness in applications.

Prerequisites: 80-311 or 80-310 or 80-211

80-314 Logic and Artificial Intelligence

Intermittent: 9 units

Logic has played a central role in the development of artificial intelligence, and continues to do so today. The first half of the course will be on "classical" logical AI, starting with Newell & Simon's General Problem Solver and McCarthy's Situation Calculus, before moving on to more recent developments in default reasoning, logic programming, epistemic logic, and description logic. After discussing links between non-monotonic reasoning and probability, the second half of the course will focus on current attempts to combine logic and probability/statistics for AI applications, including Markov Logic, probabilistic programming approaches, and several others. We will highlight the logical aspects of these tools, and more generally discuss the role logic can play in modern AI. Philosophical issues in AI will also be discussed. Prerequisites: Background in both logic and artificial intelligence would be useful. However, a solid background in one but not the other should also be fine. We will assume basic (propositional and first-order) logic as well as basic probability.

80-315 Modal Logic

Fall: 9 units

This course is an introduction to modal logic and its applications in philosophy, computer science, linguistics, and economics. The first part of the course is a rigorous development of propositional modal logic: the basic language, interpretation in relational structures, axiom systems, proofs, and validity. We will prove soundness and completeness of various systems using the canonical model method, examine notions of model equivalence, establish the finite model property, and discuss decidability and basic complexity results. We will also consider alternatives to relational structures, such as topological semantics and neighbourhood semantics, and introduce modal predicate logic, incorporating first-order quantification into the system. The second part of the course focuses on specific types of modality and their applications, including temporal and dynamic logics, deontic logics, logics for reasoning about counterfactuals, epistemic and doxastic logics, and justification logic. We will conclude with a detailed look at multi-agent systems, the notion of common knowledge, and a glimpse of its foundational role in game theory

80-316 Causation Probability & AI

Intermittent: 9 units

In this course we will examine foundational questions about the concepts of causality and probability, how artificial intelligence techniques can be used to solve some of the computational problems presented by the use of probabilities and representations of causal relations, and how probabilities and representations of causal relations have been incorporated into recently developed expert systems. The foundational questions we will examine are: What do causal and probabilistic statements mean? How can probabilities and causal relations be inferred? Are there any axioms relating causal relations to probability distributions? What are the advantages and disadvantages of using probabilities as compared to alternative representations of uncertainty? We will then discuss recent developments in Artificial Intelligence (e.g. Bayesian networks) which have solved some of the long-standing computational problems associated with the use of probabilities and statements about causal relations. Finally, we will study in detail some expert systems, such as QMR and Pathfinder, which have incorporated these new techniques in order to perform medical diagnosis.

Prerequisites: 36-217 or 36-226 or 36-202

80-321 Causation, Law, and Social Policy

Intermittent: 9 units

Policy makers face causal questions. For example, does violence on TV cause violence in life, and if so, what policies can we institute that will actually curb it? Does the death penalty actually deter criminals? Do tough drug laws reduce drug use? This course investigates how scientists establish causal claims, and how policy makers and the courts rely on or systematically ignore such science. We examine what causal claims mean and how they connect to statistical data, and we discuss the limits of standard techniques for establishing causal claims. We will consider all of these issues first theoretically, and then in the context of several case studies chosen mostly by the students. Knowledge of social science and/or statistics is not required, but is desirable.

Prerequisite: 36-201

80-322 Philosophy of Physics

Intermittent: 9 units

Philosophical problems in the development of modern physics. Topics include the philosophical significance of Einstein's theory of relativity, interpretations of quantum mechanics, and the relationship between these two theories. Other topics may include the philosophy of space and time, the epistemology of geometry, the significance of modern cosmology, and chaos theory.

80-323 Philosophy of Biology

Intermittent: 9 units

This course will examine a range of foundational problems in evolutionary biology, as well as the implications of evolutionary biology for some basic topics in philosophy. Issues to be discussed include the meanings and roles of a variety of central concepts (such as species, fitness, function and adaptation) and controversies over adaptationism, genetic information, units of selection and the evolutionary explanation of human behavior. This course will be accessible both to philosophers interested in the epistemological and metaphysical status of evolutionary biology, and to biologists interested in better understanding the foundations of their field. Although there are no formal prerequisites for this course, students will be expected to have taken courses in either philosophy or biology.

80-324 Philosophy of Economics

Intermittent: 9 units

The science of economics has come to occupy a central position in contemporary society. Because of this central position in political decision making, economics is intertwined with a number of other philosophical issues surrounding justice, rights, and fairness. The central theme of this course will be on the arguments in favor and against markets as effective solutions to political problems. This issue will allow us to analyze a wide number of foundational issues in economics including the testability of economic claims, the use of "rationality" postulates, the foundation of the right to property, and measuring the success or failure of an economy.

80-335 Deliberative Democracy: Theory and Practice

Intermittent: 9 units

This course will explore the theory and practice of deliberative democracy. Topics and concepts to be discussed include distinctions between aggregative and deliberative models of democracy, the notions of Reciprocity, Publicity, and Accountability as they apply to policy discussions, and recent work in Citizenship Theory. We will also look at various practices that utilize the theories of deliberative democracy, such as Participatory Budget Planning, Deliberative Polls®, and Action Forums.

80-337 Philosophy, Politics & Economics

Intermittent: 9 units

The course is split between two broad topics. First, we explore issues pertaining to Individual Decision Theory, mainly the postulate of rationality and its implications. We then proceed to discuss collective decision making by a group of rational agents. We discuss methods of aggregating individual preferences and, in particular, measures of social welfare, in an effort to associate the evaluation of policy with ethical principles.

80-341 Computers, Society and Ethics

Intermittent: 9 units

This course explores many of the social and ethical issues that have emerged in the wake of the significant advances that we have witnessed in computer science and information technology (IT). Computers and communications technologies have had an increasing impact on the whole of society and have raised new and difficult ethical questions. In turn, these ethical issues have spurred the need for a consideration of new policies and regulations. In this new world of IT, some are concerned about the protection of their privacy while others find problems of censorship and, more generally, restrictions on information access to be their main focus as a problematic social issue. This course will address these and other issues such as: questions of free speech, surveillance in the workplace, intellectual property and copyright, information acquisition and ethics and the Internet.

80-344 Management, Environment, and Ethics

Intermittent: 9 units

This course examines and poses answers to the following question: "What are the legitimate environmental responsibilities of organizational managers from the private, public and nonprofit sectors and how can they be best fulfilled?" This query will provide the course with its major theme and framework. But in order to do justice to it, three interrelated areas that are presupposed by this question will need to be explored first. These areas are: 1) applied ethics, 2) management ethics and 3) environmental ethics. The first half of the course will concentrate upon these three areas. The second half of the course will focus upon management and the environment employing the insights gained during the first half. Here students will review and evaluate past and current management practices with respect to the environment, organizational policies dealing with the environment and the role of government in the process of determining environmental responsibilities in management. Environmental concerns on the international level and their impact upon organizational management, the emergence of the "environmental affairs manager" within organizations, balancing environmental responsibilities with other management responsibilities and examples of management responses to the environmental crises will also be examined during this portion of the course.

80-348 Health Development and Human Rights

Fall: 9 units

Approximately 1.1 billion people live on less than \$1 a day in a condition the World Bank refers to as extreme poverty. Those who live in extreme poverty frequently lack effective access to proper nutrition, adequate shelter, safe drinking water, and sanitation. As a result, they also bear the greatest burdens of famine and epidemic disease and frequently face social and political conditions of unrest and systematic oppression. This course examines the question of what, if anything, we in the technologically and economically developed world owe to the global poor. It therefore focuses considerable attention on competing theories of global distributive justice and the relationship between poverty, poor health, and human rights. We will critically examine different strategies for international development that emphasize one or more of these variables and we will consider how information about the complex interrelationship of these variables should be factored into the development process.

80-363 19th Century Foundations of Science

Intermittent: 9 units

Why do contemporary philosophers of science worry about the relationship between theory and evidence, or what is it for some event to cause another? These issues are not new, but have a rich history in the debates among philosophers and scientists in the 19th and early 20th century. This course will explore the roots of contemporary debates in the works of Mill, Herschel, Whewell, Poincare; Maxwell, Hertz, Duhem, and Mach. We will examine the issues of theories and evidence, scientific realism, the role of models in science, the role of mathematics in science, concepts of space and time, and ascription of causal relationships. The specific direction taken by the class will be determined, in part, by the interests of the students who enroll.

80-365 Ramsey

Intermittent: 9 units

Frank Ramsey played a crucial intellectual role in the Cambridge of Russell, Moore, Wittgenstein and Keynes (just to mention some central figures of the exceptionally lively and creative atmosphere of Cambridge at the beginning of the past century). During his short life (he died in 1930 at the age of only 26) he made decisive contributions to epistemology, decision theory, philosophical and mathematical logic, philosophy of mathematics, metaphysics and philosophy of science. Just to mention an example, his paper 'Truth and Probability' laid the foundations of the modern theory of subjective probability and also those of modern utility theory and decision theory. The entire core of Ramsey's philosophical and scientific work consists of no more than 15 papers. But in all cases they are remarkable essays that changed the intellectual topics they touched. Moreover they all contain the same view of philosophy merging a sound portion of Moorean realism with Ramsey's kind of pragmatist philosophy. The course reviews these central papers and its rich relations with the Cambridge philosophers of this time and the Vienna Circle. In addition it is remarkable that most of Ramsey's views remain valid today almost a century after his death. So, the course considers as well the impact of Ramsey's views in contemporary analytic philosophers and those influenced by early American pragmatism. The Ramsey Collection at the University of Pittsburgh comprises an almost complete collection of autograph material by Ramsey, roughly 1.500 autograph pages in all. I am doing some historical research on this material which I intend to incorporate as additional material for the course.

80-380 Philosophy of Language

Intermittent: 9 units

There is a robust interplay between the study of language in philosophy, and the study of meaning in current linguistics. Many of the foundational concepts on which linguistic semantics and pragmatics are based were developed by philosophers, or have been examined and critiqued by philosophers. In the other direction, some philosophers have adopted linguistic theories and methodologies in pursuing philosophical questions about language. This course will examine a sequence of topics in linguistic philosophy and philosophical linguistics. The primary focus will be on exploring the philosophical foundations of current work in linguistic semantics and pragmatics. Rather than presenting a standard survey of classical work in the philosophy of language, the course will focus on philosophical work which is of relevance to the practice of linguistics today. The course will involve detailed reading of papers taken from the literature, some of them of a technical nature. All relevant concepts will be explained, but students need to be willing to grapple with difficult material. The course can be taken as a stand-alone course, and no special knowledge of linguistics will be assumed. However, the course may be of particular interest to students who have taken or are taking courses in semantics and pragmatics, and wish to deepen their understanding of fundamental concepts in those domains. In general, the course should be of interest to any students who would like to understand the foundations of current approaches to the systematic study of linguistic meaning.
Prerequisites: 80-100 or 76-101

80-381 Meaning in Language

Intermittent: 9 units

Human language involves an association between arbitrary signs and meaning. The study of meaning in language, semantics, is a recently developed subfield of linguistics, since it presupposes advances in phonology, morphology, and syntactic structure. In addition, semantics faces the conceptual challenge of saying what meaning is. This course will reflect the history of semantics within linguistic theory and examine solutions to the problem of the definition of meaning. The course begins with the meanings of words and examines how these meanings combine to give the meanings of sentences, based on the notion of truth conditions for indicative sentences. That notion of meaning is then extended to sentences in other moods, and to sentences that do not simply describe how the world is, including sentences which are modal, conditional, or simply fictional. Semantics is a subject that can be developed in a highly formal way, but here it will be presented to make it accessible to students with varied backgrounds and interests. The components of the resulting theory will apply to any human language, and be an important component in the toolkit of any student of language.
Prerequisite: 80-180

80-382 Phonetics and Phonology II

Intermittent: 9 units

This course is a continuation of Phonetics and Phonology I (80-282) and is designed to expand upon the phonetic skills developed in that course, while delving more thoroughly into various issues central to phonology. We will focus primarily on consonants and the phonetic principles that govern their realization, with a special emphasis on voicing. We will learn about how articulatory and acoustic principles give rise to voicing assimilation, final devoicing and the interaction of consonant voicing and tone. The exploration will be hands on, and we will learn how to measure voice onset time, analyze stop bursts and fricative noise and see how the voicing of a consonant affects the pitch of the following vowel, using Praat. On the phonological side, we will consider various ways in which voicing contrasts and processes have been represented, including SPE-style binary features, feature geometry and Optimality Theory. One of the central themes will be how to reconcile phonological accounts of voicing phenomena with our understanding of their underlying phonetic principles. Both rule-based and constraint-based approaches to phonology rely on discrete symbols, whether they be phones or features, but the speech stream is not neatly divided into segment-sized units, and the features of phonological theory are typically spread over multiple segments. Additionally, many phonological explanations recapitulate phonetic principles, calling into question what we consider to be an explanation of sound patterns. The course will culminate in a survey of some recent approaches to understanding how phonetics and phonology interact.
Prerequisites: 80-282 and 80-180

80-383 Language in Use

Intermittent: 9 units

We use language to convey meaning. But not all of what we mean is contained in the language that we use. Suppose you ask me, "Is Jane coming to the party?" and I reply "She has to finish her homework." The pronoun "she" encodes the information that I am referring to some female individual, but does not encode the information that I intend to refer specifically to Jane. This, the addressee has to figure out given the use of the sentence in that particular context. Nor does the sentence encode the actual answer to the original question. It is clear in the context that the intended answer is "no"; but again, this is something which the speaker relies on the hearer being able to figure out in the context of use. The investigation of inferences about speaker meaning that arise from the use of language in particular contexts is part of the field of linguistic pragmatics, which is the topic of this course. Linguistic pragmatics is also, though, concerned with some aspects of encoded meaning: specifically, the meanings of words and constructions which indicate such things as the function of a sentence in discourse, the speaker's attitude to what she is saying, or her evidence for it. This course provides an introduction to the investigation of both types of pragmatic features of language.

Prerequisites: 80-180 or 80-100

80-384 Linguistics of Turkic Languages

Intermittent: 9 units

In this course we will look at the phonology, morphology, syntax and writing systems of languages within a single language group, Turkic. Turkic languages are spoken across continental Asia and include such languages as Turkmen, Tatar, Kazakh, Kirghiz, and Uzbek. In this course we will concentrate especially on Turkish, Azerbaijani, and Yakut. We will look at the sound systems of these languages to discover how they are related, and we will also look comparatively at various morphological and syntactic structures. We will consider the impact of diachronic factors on the synchronic study of language, and we will also examine certain recent techniques used to establish genetic relations between languages. To a large extent the course will be student-driven, and it can be seen as an extended case-study for applying concepts and analytical strategies taught in Nature of Language, Phonetics and Phonology, Linguistic Analysis, and other relevant courses.

Prerequisite: 80-180

80-385 Linguistics of Germanic Languages

Intermittent: 9 units

The Germanic languages include English, Dutch, Frisian, German, Pennsylvanisch, Afrikaans, Yiddish, Icelandic and the Scandinavian languages, excluding Finnish. The course will serve as an extended case-study for the application of concepts and analytical strategies taught in basic linguistics courses to some of these languages. Specifically, we take a bottom-up approach to Dutch, Frisian, Icelandic, and Danish, starting with raw language material whenever possible, which we progressively analyze in terms of phonetics and phonology, morphology, and syntax. These case studies lead to comparisons between the languages and insight into their development and divergence over time. We follow this hands-on approach with historical and grammatical overviews, touching on some of the outstanding issues in Germanic linguistics. The approach should also help bring out the relevance of diachronic factors in the synchronic study of language, with historical forms of English being open to investigation, as these often reflect patterns found in contemporary Germanic languages.

Prerequisite: 80-180

80-391 Morality Play: Laboratory for Interactive Media and Values Education

Intermittent: 12 units

What do you get when you cross cutting edge interactive media technologies with inquiry into the big questions of human existence? Let's find out! New technologies-including online gaming, interactive film, "social" media, podcasts and smartphone apps-have enormous potential to change the way people learn. Especially intriguing is their potential to promote active, exploratory learning. We have only scratched the surface of this potential. Imagine interactive technologies that impart a deep understanding of the human condition. Imagine the compelling motivational strategies of well-designed games used to spark inquiry and scientific curiosity. Imagine immersive experiences that deepen our capacity for critical thinking, empathy or compassion. What if we applied absorbing interactive media to the task of delivering a first-rate humane education? In this course, we will explore a topic of elemental human concern (e.g. inequality, abortion and human reproduction, the nature of the social contract, the separation of church and state, population and sustainability?) and develop a deep, interdisciplinary understanding of the issue. Then, instead of producing a term paper, we'll collaborate with a team from CMU's Entertainment Technology Center (ETC) to design and prototype a next-generation learning tool that brings the issue to life. The result will push the boundaries of what is possible in the way of technologically mediated learning.

80-405 Game Theory

Intermittent: 9 units

Game theory is the study of interactive decision-making. This course will develop conceptual and technical facility with the mathematical tools used to model and analyze such strategic scenarios. We will cover games in strategic and extensive form, games of perfect and imperfect information, Bayesian games, and repeated games. We will examine a variety of solution concepts such as Nash equilibrium and rationalizability, and compare their classical formulations to their epistemic characterizations. We will also discuss results in experimental economics that call into question some of the assumptions of standard game theory, and explore generalizations of the classical setting meant to address some of these concerns.

80-411 Proof Theory

Intermittent: 9 units

Proof Theory is one of the core subjects of mathematical logic. It interacts with central issues in computer science, artificial intelligence as well as mathematics but also with broader methodological, philosophical questions. This course presents a theory of formal proofs that serve to represent mathematical arguments. We first study proofs in natural deduction and sequent calculi. We show that every proof is reducible to a normal one; normal proofs have an important internal structure and are critical for automated theorem proving and proof search. They are also critical for metamathematical studies that concern, for example, consistency and decidability. We then examine frameworks for the formalization of mathematical practice: starting with arithmetic and ending with Zermelo-Fraenkel set theory, after having made a detour through Church's simple type theory. As strict formalization is here not just a matter of principle but of real practice, we will discuss interactive theorem proving systems (AProS, Isabelle, Twelf) that can be used for the formal verification of mathematical proofs. Finally, Gödel's second incompleteness theorem (of 1931) is the starting point for considering an extension of Hilbert's finitist consistency program. (We will establish Gödel's theorem for set theory and arithmetic.) We present, as a paradigm of pre-Gödelian investigations, the consistency proof Hilbert & Bernays gave in 1922 for a quantifier-free part of arithmetic. Then we discuss the Gödel-Gentzen-reduction of classical to intuitionist arithmetic and present Gentzen's 1936 consistency proof of the latter by transfinite induction (up to ϵ_0). At every stage of our investigations, we will pay particular attention to a more external, conceptual structure of proofs that facilitates interactive theorem proving and lays the basis for automated proof search as well.

Prerequisites: 21-300 or 80-310 or 80-311

80-413 Category Theory

Intermittent: 9 units

Category theory is a formal framework devoted to studying the structural relationships between mathematical objects. Developed in the mid-20th century to attack geometrical problems, subsequent progress has revealed deep connections to algebra and logic, as well as to mathematical physics and computer science. The course emphasizes two perspectives. On one hand, we develop the basic theory of categories, regarded as mathematical structures in their own right. At the same time, we will consider the application of these results to concrete examples from logic and algebra. Some familiarity with abstract algebra or logic required.

80-414 Seminar on Computability

Intermittent: 9 units

This interdisciplinary seminar is divided into three parts. Part 1 reviews the emergence of the computability concept and arguments for Church's or Turing's Thesis; it presents then, in sharp contrast, an axiomatic characterization of serial and parallel computability. Part 2 takes up the considerations of Gödel, Turing and Post to relate machines and the human mind, in particular, with respect to mathematics. Finally, Part 3 discusses the use of computations in cognitive psychology to model aspects of human minds; the focus is on (Post-) production systems and parallel-distributed processes.

Prerequisite: 80-311

80-430 Ethics and Medical Research

Intermittent: 9 units

Ethics & Medical Research: This course covers foundational issues in the ethical evaluation and regulation of research involving human subjects. It begins with a historical overview of the origins of research ethics after World War II as a response to high profile cases of abuse or scandal. This unit covers "classic cases" including the Tuskegee syphilis study, the Willowbrook hepatitis study, the Jewish Chronic Disease Hospital Case, and others. It also covers seminal documents such as the Nuremberg Code, the Belmont Report, and the current federal regulations known as the Common Rule. Against this historical backdrop, the course then examines foundational philosophical issues in human-subjects research including ethical issues in clinical trial design, the concept of equipoise and the use of placebo controls, the requirements of justice in the research context, and the values of privacy and informed consent.

80-431 Meta-ethics

Fall: 9 units

First we will survey of proposals for necessary and sufficient conditions for "x is a morally permissible act". Then we will consider T.S. Scanlon's claim that metaethics is immune from criticism from other subjects. We will then consider moral voting rules—varieties of consequentialism and Scanlon's winner take all method of reasons. We will take up arguments that there are, or are not moral facts, and moral particularism—the doctrine that while there are moral facts, there are no informative true moral generalizations. Finally, we will consider biological accounts of the sources of morality and agency by Binmore, Kitcheer, Churchland and others, and there force, if any, against the very idea of normative ethics.

80-447 Global Justice

Intermittent: 9 units

Until recently, the dominant view of international relations has been that the governments and citizens of one country have no moral obligations to those beyond their borders. With the rapid growth in globalization has come a drastic shift in attitudes about our obligations to those with whom we share global institutions of trade but neither legal systems nor national identities. This course aims to introduce students to the problem of global distributive justice in the context of a globalized world, with emphases on both theoretical accounts of justice and the practical implications of those accounts for important current issues. Theoretical topics will include the nature of justice, the sources and limits of our moral obligations, and how and whether those notions of justice extend to global society; while applied topics will include our obligations with regard to the environment, human rights deficits, the status of women, and global economic policy.

80-449 EHPP Project Course

Fall: 12 units

The Ethics, History and Public Policy Project Course is required for the Ethics, History and Public Policy major and is taken in the fall semester of the senior year. In this capstone course, Ethics, History and Public Policy majors carry out a collaborative research project that examines a compelling current policy issue that can be illuminated with historical research and philosophical and policy analysis. The students develop an original research report based on both archival and contemporary policy analysis and they present their results to a client organization in the community.

80-501 Philosophy Senior Honors Thesis I

Fall: 9 units

Philosophy Department majors with outstanding academic records and intellectual promise will be given the opportunity to earn Dietrich College Honors by engaging in original research under the direction of an individual faculty member. Research topics are selected by student. Students must submit a proposal to the Dean's Office for permission.

80-502 Philosophy Senior Honors Thesis II

Spring: 9 units

Philosophy Department majors with outstanding academic records and intellectual promise will be given the opportunity to earn Dietrich College Honors by engaging in original research under the direction of an individual faculty member. Research topics are selected by student. Students must submit a proposal to the Dean's Office for permission.

80-511 Thesis Seminar

Spring: 9 units

This course provides a forum for the presentation and detailed discussion of research done by students, be they undergraduates working on their Senior Thesis or graduate students engaged with their M.S. thesis.

80-513 Seminar on Philosophy of Mathematics

Intermittent: 9 units

The "linguistic turn" in twentieth century philosophy lets us think about mathematics as a collection of linguistic rules and norms that helps us reason effectively and make sense of our experiences. The advent of computational proof assistants, which use stylized languages to convey mathematical content, provides new perspectives on these rules and norms. This seminar will explore ways these formal models of mathematical language and inference can be brought to bear on traditional questions in the philosophy of mathematics.

80-514 Categorical Logic Seminar

Intermittent: 9 units

This course focuses on applications of category theory in logic and computer science. A leading idea is functorial semantics, according to which a model of a logical theory is a set-valued functor on a category determined by the theory. This gives rise to a syntax-invariant notion of a theory and introduces many algebraic methods into logic, leading naturally to the universal and other general models that distinguish functorial from classical semantics. Such categorical models occur, for example, in denotational semantics. e.g. treating the lambda-calculus via the theory of Cartesian closed categories. Similarly, higher-order logic is treated categorically by the theory of topoi. Note: this course will begin with a 3 week refresher of basic category theory - CS students can start after immigration by reviewing on their own.

Prerequisite: 80-413

80-515 Seminar on the Foundations of Statistics

Intermittent: 9 units

This decision-theoretic seminar is organized in three parts. 1. In the first we examine Savage's theory of subjective expected utility, primarily chapters 2-5 of his classic book, *The Foundations of Statistics*. 2. In the second part of the course, we focus on the following issues: 2.1. A comparison of Savage's theory and deFinetti's criteria of coherence. 2.2. Personal vs. group decisions. Topics to include: Arrow's impossibility theorem, consensus, and Savage's position in §7.2 & §13.5 of his book. 2.3. Contemporary theories that highlight violations of the sure-thing principle — violations of Savage's postulate P2. 3. For the third part, we discuss issues related to Indeterministic and/or Imprecise Probability [IP] theory. The seminar explores some of the ongoing research programs falling under IP, mostly as reflected in the Society for Imprecise Probability: Theories and Applications (www.sipta.org).

80-516 Seminar on Causation

Fall

In the past decades, many influential developments in the study of causation have resulted from cross-disciplinary efforts. This course explores the foundations of causation, emerging approaches to causal discovery (discovering causal relationships from observational data) and inference developed in various fields (e.g., philosophy, machine learning, statistics, and artificial intelligence), and the unique benefit of using causal knowledge. We encourage participants to bring causal problems in their respective fields and promote cutting-edge interdisciplinary research on causation and its applications.

80-517 Game Theory and the Evolution of Signaling

Spring

Game Theory and the Evolution of Signaling Description: The evolution of simple languages, known as signaling systems, has received a lot of recent attention from game theorists in philosophy, biology, and economics; this will be the focus of our course. In the first half, we will look at several evolutionary and learning models of "costless" signaling. In addition to analyzing the plausibility of these as models for the evolution of proto-languages, we will consider the ways this model has been applied to some old philosophical problems (convention, meaning, natural kinds, and the descriptive/normative distinction). One handy feature of signaling games is that many different modeling strategies have been applied to them. This will give us an opportunity to see the variety of strategies used in this fast expanding literature. In the second half of the course we will turn to different models of the evolution of language which relax the pure common interest assumption. Here we will look at the problem of "signal cost" (e.g. "handicaps") and attempt to determine the extent to which this feature expands the set of explanations available for the evolution of simple languages. Costly signaling has been used primarily by both biologists and economists and we will have a look at the similarities between these two approaches.

80-518 Seminar on Topics in Logic

Intermittent

Topic: Intuitionism and Constructive Mathematics In this seminar we shall read primary and secondary sources on the origins and developments of intuitionism and constructive mathematics from Brouwer and the Russian constructivists, Bishop, Martin-Löf, up to and including modern developments such a homotopy type theory. We shall focus both on philosophical and metamathematical aspects. Topics could include the Brouwer-Heyting-Kolmogorov (BHK) interpretation, Kripke models, topological semantics, the Curry-Howard correspondence with constructive type theories, constructive set theory, realizability, relation to topos theory, formal topology, meaning explanations, homotopy type theory, and/or additional topics according to the interests of participants.

80-520 Seminar on Philosophy Science

Intermittent: 9 units

Seminar on Philosophy of Science: Evolutionary Game Theory and Applications Evolutionary game theory (EGT) represents one potential foundational theory which grounds traditional game theory models. EGT relaxes the "high rationality" assumptions of traditional game theory in favor of conceptualizing individuals as subject to evolution by natural selection or some form of trial and error learning. EGT provides a justification for many of the traditional concepts in game theory, but also highlights potential problems with this theory. This course will provide an overview of evolutionary game theory, and then will investigate two applications of that theory. The first application is the explanation of pro-social behaviors including cooperation, fairness, and altruism. The second application is to the emergence of linguistic behaviors, especially in non-human animals.

Prerequisites: 80-413 or 80-713

80-521 Seminar on Formal Epistemology

Spring

Formal epistemology applies systematic mathematical models from logic, statistics, and computability theory to provide fresh perspectives on traditional epistemological questions regarding the nature of epistemic justification, vagueness, paradoxes of knowing, paradoxes of rationality, the nature of bounded rationality, and the connection between coherence, epistemic justification and truth. The course will critically examine published papers, many of which were presented at the Formal Epistemology Workshop in recent years.

80-530 Seminar on Ethical Theory

Intermittent

This seminar will focus on classic and contemporary accounts of moral and political autonomy and their application to current topics in ethics, political philosophy, and global justice. We will pay especial attention to the neorepublican notion of freedom as non-domination, how and to what extent this concept interacts with competing conceptions of autonomy, and what can be gained or lost by applying the neorepublican framework to various debates.

80-575 Seminar on Metaphysics

Intermittent

We will begin, appropriately, with readings from Plato and from Aristotle's *Metaphysics*, which motivate the fundamental questions of metaphysics. With this classical background, we will turn to a range of exemplary contemporary articles concerning such traditional metaphysical questions as the nature of existence, necessity, and causation, the persistence of objects through time, and personal identity. This is an advanced undergraduate class.

80-580 Seminar on the Philosophy of Language

Intermittent: 9 units

The study of the semantics of natural language quantifiers (e.g., 'some', 'no', 'many', 'fewer', 'most', and 'always') brings together themes from linguistic semantics, metamathematics, and the philosophy of logic. In this seminar, we will discuss a selection of writings on the semantics of quantification, with an emphasis linguistic applications of generalize quantifier theory, possible semantic universals of human language, and the expressive power of natural language quantificational devices. Specific topics may include plural quantification, adverbial quantification, structure-sensitive 'non-logical' aspects of natural language quantification, and basic methods for comparing expressive power of formal languages equipped with different linguistically-motivated quantifiers.

80-595 Senior Thesis

Fall and Spring

Philosophy Department majors writing a senior thesis, and are not participating in the Dietrich College Senior Honors Program, are given the opportunity to engage in original research under the direction of an individual faculty member. Research topics are selected by student.

Physical Education Courses

69-005 Rec Sports

Fall and Spring: 3 units

Rec sports is a class that will incorporate sports from our intramural program. The class will focus on a variety sports including: flag football, soccer, basketball, dodgeball, softball and additional recreational games.

69-101 Racquetball

Fall and Spring: 3 units

This course is designed to aid in developing the fundamental skills involved in racquetball. Techniques, rules and strategy are stressed. It is hoped that the student will develop a reasonable level of proficiency to enable participation on a leisure-time basis.

69-102 Weight Training

Fall and Spring: 3 units

This course is designed to provide the opportunity for the inexperienced student to learn the effectiveness of a carefully planned weight-training program as a method of body development and the contributing benefit to performance in many sports.

69-103 Advanced Recovery & Restoration

Spring: 3 units

This course is designed to provide the opportunity for the physically active student to learn the effectiveness of a carefully planned recovery and restoration techniques as a method of body development and the contributing benefit to performance in many sports.

69-104 Practical Application of Sports Nutrition for Competitive Athletes

Spring: 3 units

This course will cover the following topics: macronutrient overview, specific overview of fats, carbohydrates, and protein, vitamin and minerals, nutritional needs for strength/power and endurance athletes, pre/during/post training nutritional needs for strength/power and endurance athletes, and other topics. FOR UNDERGRAD STUDENTS ONLY.

69-105 Agility & Circuit Training

Spring: 3 units

This course is designed to train the entire body combining fitness and core body work. We will do jumping and agility exercises to increase explosiveness and foot speed. Circuit training will be used to strengthen your core, arm, and leg muscles and will provide a cardiovascular workout.

69-106 Intro to Recreation

Fall: 3 units

This is a basic level class for first-year students only. This class is designed to teach students various fitness and recreational activities available to them on campus.

69-107 Walking for Fitness

Fall: 3 units

This course is an aerobic conditioning activity. A fast paced walk that is less wear and tear on your joints than what a running program will do.

69-110 Personal Fitness

Fall and Spring: 3 units

This course will be a conditioning course prescribed partially by the individual with assistance from the instructor to insure that the desired results will be achieved or at least pursued correctly. Individual goals will be the main concern. Stretching, aerobics, weight training and nutrition will be discussed.

69-112 Fitness Fusion

Fall and Spring: 3 units

A fun power-packed workout designed to introduce all aspects of fitness. This class combines simple exercises including cardio endurance with dynamic balance and stabilization. The class will fuse fitness while maximizing the benefits offered by training with concise, innovative, and effective exercises for the whole body. Every few weeks another aerobic activity will be added. We will start slowly so you can experience progressions and advance your training. During the fusion of strength, core, and flexibility, we will use a variety of "toys" to enhance your fun and fitness while fusing the total package of mind, body, and spirit.

69-113 Beginning Karate

Fall and Spring: 3 units

Beginning Karate teaches traditional Tang Soo Do (Korean Karate) by Master C. S. Kim and assistant instructors with specific standards and goals designed to help each student maximize potential as an individual, as well as a martial artist. Students will learn stretching and basic stances as well as blocking, punching, kicking, knee and elbow strikes, and open-handed techniques such as knife-hands. Proper etiquette will also be taught.

69-114 Intermediate Karate

Fall and Spring: 3 units

Intermediate Karate teaches a higher level of the traditional martial arts with specific standards and goals designed to help each student maximize potential as an individual, as well as a martial artist. Through traditional Tang Soo Do (Korean Karate) taught by Master C. S. Kim and assistant instructors, you will find many opportunities to gain specific knowledge which will apply not only in your martial arts training, but also in the improvement of your daily quality of life.

69-129 Rape Aggression Defense Systems (RAD)

Fall and Spring: 3 units

Self Defense for Women - is a course specifically designed to increase women's awareness of potential sexual assault and to provide physical techniques to respond to such an act. It is intended for women only because it is believed that the presence of males in class (other than instructors or other authorized persons) can alter the emotional and physical responses of women to class material and thereby hinder their ability to reach course objectives. It is of the utmost importance that women be able to maximize their opportunity to learn in the company of like-minded students. The core of the course is based upon the principles of the Rape Aggression Defense System (R.A.D.) which was conceived and developed by Larry N. Nadeau. His goal in developing R.A.D. is also its motto: "To develop and enhance the options of self-defense, so they may become viable considerations to the woman who is attacked." This course is composed of three sections: risk reduction principles, physical defense techniques, and simulation. Risk reduction principles include a thorough review of personal self-awareness & the environment, whether in the home, neighborhood, or unfamiliar community. Physical defense techniques include the introduction to bodily strikes with hands, kicks with the feet, and defenses against grabs & holds. Simulation is the activity that attempts to incorporate, via physical demonstration, all emotional & physical techniques that have been taught through the acting out of scenarios involving instructors (padded/protected) as attackers, and students (padded/protected) responding to the assault.

69-130 Beginning Tennis

Fall and Spring: 3 units

This course is designed to familiarize the student with the rules of tennis and to develop the skills needed to become proficient for recreational play. During the first half of the course, all tennis strokes will be covered and reviewed in detail. The second half of the course will focus mostly on competitive games and match-play.

69-131 Volleyball

Spring: 3 units

This course is designed to familiarize the student with the rules of volleyball and to develop the skills needed to become proficient for recreational play.

69-132 Advanced Tennis

Fall: 3 units

This course will consist mainly of tennis drills and discussions related to singles, doubles, and match strategy. In addition to being able to successfully execute all tennis strokes, students should also already have significant tennis match experience.

69-134 Beginning Golf

Fall and Spring: 3 units

This course is designed to give the student all the skills necessary to play a satisfactory game of golf. The long game, the short game and putting are covered. It is a leisure time sport that is challenging and can be used by the student for the rest of his/her life.

69-135 Soccer Skills

Spring: 3 units

This course is designed to familiarize the student with the rules of soccer and to develop the skills needed to become proficient for recreational play.

69-136 Basketball Skills

Fall and Spring: 3 units

This course is designed to familiarize the student with the rules of basketball and to develop the skills needed to become proficient for recreational play.

69-137 Ultimate Frisbee

Fall: 3 units

This class is designed to teach basic Frisbee skills. This class is a great conditioning/cardio class with high energy. It is a fun team game to play.

69-139 Indoor Soccer Skills

Spring: 3 units

This course is designed to familiarize the student with the rules of soccer and to develop the skills needed to become proficient for recreational play.

69-140 Squash

Fall and Spring: 3 units

This course is designed to aid in developing the fundamental skills involved in squash. Techniques, rules and strategy are stressed.

69-141 Beginning Soccer

Spring: 3 units

This class is designed for beginner soccer players. This class will teach you soccer skills and techniques to become a better player.

69-142 Beginning Fencing

Spring: 6 units

This course will cover the basic skills needed for fencing with the foil. Footwork, attacks, and defenses will be practiced. Competition rules and strategies will be discussed. Students will fence each other and the instructor in almost every class.

69-143 Floor Hockey/Dodgeball

Spring: 3 units

This class is designed to teach two team sports that are fun and great exercise. Both classes will be taught basic skills to succeed in the games.

69-144 Diamond Sports

Spring: 3 units

This course is designed to familiarize the student with the rules of softball and wiffleball and to develop the skills needed to become proficient for recreational play. Students will play each other or the instructor in almost every class.

69-145 Sports Officiating

Fall and Spring: 3 units

The sports officiating class is an introduction to the rules and mechanics for a variety of Intramural Sports. Students will learn how to properly officiate basketball, flag football, soccer, and softball. Class sessions will be a combination of interactive lectures and hands-on game experience.

69-146 Team Handball

Fall: 3 units

Team Handball or European Handball - This is an introductory level class that will cover the basics of the sport including the rules, organization, and basic game play. Students will be expected to learn the rules and participate in play on a daily basis.

69-150 Beginning Swimming

Fall: 3 units

This basic course is designed to equip the non-swimmer with fundamental skills and knowledge to assure reasonable safety in, on or about the water. Areas covered include the basic swimming strokes, basic diving, safe and efficient entry into the water, and some elementary forms of rescue.

69-151 Introduction to Yoga

Fall and Spring: 3 units

This course is designed for the beginning yoga student who wants to gain a solid foundation of yoga poses and the benefits a yoga practice has to offer. The course is also for those who have experience in Yoga and want to practice and improve their basic skills.

69-153 Lifeguard Training

Spring: 3 units

This class is the American Red Cross Lifeguard Training course. Students who complete certification will be eligible to be employed as lifeguards. Attendance is required. There will be a \$90.00 fee for this class from the American Red Cross. This fee will be deducted from the student's account once the status of the student is "enrolled and attending this class."

69-155 Cardio Fitness/Sculpt

Fall and Spring: 3 units

A total body fitness class for men and women that incorporates stretching for flexibility, exercises for strength and movement to increase cardiovascular improvement.

69-156 First Aid/CPR

Spring: 3 units

A basic course in treatment and care of injuries in emergency situations. Topics will include legal liability, prevention of injuries, nutrition and cardiovascular conditioning. The course will conclude with theoretical and practical application of cardiopulmonary resuscitation. Upon completion of the course students will receive Red Cross Certification. There will be a fee for this class of \$15.00. This fee will be deducted from the student's account.

69-157 Swimming Stroke Improvement

Fall: 3 units

This course is designed to provide the student with the opportunity to learn the elements of good swimming. A wide range of strokes, basic diving, safety, endurance, and versatility in the water will be covered for all students. Experienced swimmers will have the opportunity to perfect their strokes.

69-160 Swim-Fit

Fall and Spring: 3 units

Must be able to complete a 1000 yard swim (40 laps) prior to entering the class; this is not a learn-to-swim class. Pre and post timed swims, deep water treading, lap swimming interval training. Average workout is around 2000 yards.

69-165 Cycling Core

Fall and Spring: 3 units

Indoor cycling classes are riding on a stationary bike while getting a great workout, experiencing several styles of training, and listening to music. All are welcome—beginner to advanced—you set the workout pace to various intensities. This course is for those participants who want to gain knowledge and experience of riding for endurance, speed work, race training, strength training, and/or visionary riding. Each class will be formatted to take the rider to their levels of advancement—beginner to advanced—all doing the same workout. Bikes are provided. No prior bike experience is necessary. No special footwear required—bike shoes are welcome—and tennis shoes at least are a must. Come along for the ride of a lifetime while having fun and getting into shape.

69-167 Bike Outdoors

Spring: 2 units

This class is designed for students looking to explore the campus surroundings while biking. Helmets are required. Bikes will be provided by Athletic Department.

69-175 African-Caribbean Dance

Fall: 2 units

This class incorporates African-Modern dance technique (specifically elements of Dunham and Horton technique) and applies it to dance movements from West Africa, Haiti, and /or Brazil. Students will build strength, alignment, and stamina while experiencing the joy of dancing to the exciting and mesmerizing music of these regions. Open to non-drama and drama majors.

69-176 Non-Majors Jazz

Spring: 3 units

This class is designed for those students who would like to continue their study in jazz but are not enrolled in the CFA department. They will learn the basics and progression movements in the area of jazz dancing. This is for all levels of participants.

69-195 Emergency Medical Technician

Spring: 6 units

The Emergency Medical Technician course enhances students' prior knowledge of Emergency Medicine, and enables students to take the National Registry EMT Certification exam and become certified at the state level. This course is cross-enrolled through the Community College of Allegheny County (CCAC) and will require registration with CCAC prior to the first day of class. This will require an approximately \$250 fee. Due to state laws and classroom hours requirements, all lectures are mandatory. Although listed as a Mini3/Full Semester, this class will begin on Monday, January 12th and have its last meeting on Thursday, March 26th. This class will also meet on Saturday, January 31st and Saturday February 21st from 8:00am-5:00pm. There will be one additional Saturday session for vehicle extraction during the month of March, this date will be announced in class. The following prerequisites are required to enroll in this class: Successful completion of an Emergency Medical Responder course within one year of the beginning of this class; NIMS 100 and 700 level certification (can be taken online); AHA BLS HCP Certification (Can be taken through CMU EMS). Please email info@cmuems.org with any questions you might have.

Physics Courses

33-100 Basic Experimental Physics

All Semesters: 6 units

This course provides students with a basic introduction to experimental physics. The content of the course and the particular experiments to be carried out are chosen to be especially useful for students who intend to work in the health sciences. Specific topics will range from mechanics to nuclear and atomic physics. This course is specifically geared toward pre-health students.

33-101 First Year Seminar

Fall: 3 units

Various seminars are offered that introduce first-year students to current topics of modern physics. These are mini courses that meet for half a semester. In the past, seminar topics have included: Science and Science Fiction, Astrophysics, Black Holes, Cosmology and Supernovae, Elementary Particles, and The Building Blocks of Matter. These seminars are open only to MCS first year students.

33-104 Experimental Physics

All Semesters: 9 units

This course provides first year students and sophomores with an introduction to the methods of experimental physics. Particular emphasis is placed on three aspects of experimentation: laboratory technique, including both the execution and the documentation of an experiment; data analysis, including the treatment of statistical and systematic errors and computer-aided analysis of experimental data; and written communication of experimental procedures and results. The concepts and skills for measurement and data analysis are acquired gradually through a series of experiments covering a range of topics from mechanics to nuclear and atomic physics.

33-106 Physics I for Engineering Students

Fall and Spring: 12 units

This is a first semester, calculus-based introductory physics course. Basic principles of mechanics and thermodynamics are developed. Topics include vectors, displacement, velocity, acceleration, force, equilibrium, mass, Newton's laws, gravitation, work, energy, momentum, impulse, temperature, heat, equations of state, thermodynamic processes, heat engines, refrigerators, first and second laws of thermodynamics, and the kinetic theory of gases.

Corequisite: 21-120

33-107 Physics II for Engineering Students

All Semesters: 12 units

This is the second half of a two-semester calculus-based introductory physics sequence for engineering students. The course covers waves, including standing and travelling waves, superposition, beats, reflection, interference, electricity, including electrostatics and electric fields, Gauss' law, electric potential, and simple circuits, magnetism, including magnetic forces, magnetic fields, induction and electromagnetic radiation.

Prerequisites: 33-106 and 21-120

Corequisite: 21-122

33-111 Physics I for Science Students

Fall and Spring: 12 units

This calculus based course combines the basic principles of mechanics with some quantum physics and relativity to explain nature on both a microscopic and macroscopic scale. The course will build models to describe the universe based on a small number of fundamental physics principles. Some simple computer modeling will be done to develop insight into the solving of problems using Newton's laws. Topics covered will include vectors, momentum, force, gravitation, oscillations, energy, quantum physics, center of mass motion, angular momentum, statistical physics, and the laws of thermodynamics. No computer experience is needed.

Corequisite: 21-120

33-112 Physics II for Science Students

Fall and Spring: 12 units

This is the second semester course that follows 33-111. Electricity and magnetism is developed, including the following topics: Coulomb's law, polarization, electric field, electric potential, DC circuits, magnetic field and force, magnetic induction, and the origins of electromagnetic waves.

Prerequisites: 33-111 and 21-120

Corequisite: 21-122

33-114 Physics of Musical Sound

Spring: 9 units

An introduction to the physics and psychophysics of musical sound. Elementary physics of vibrating systems. Propagation of sound: traveling waves, reflection, and diffraction. Addition of waves: interference and beats. Anatomy of the ear and the perception of sound: loudness, pitch, and timbre. Standing waves and natural modes. Qualitative description of general periodic systems by Fourier analysis: the harmonic series and complex musical tones. The acoustics of musical instruments including percussion instruments, such as drums, bars, and struck and plucked strings; and instruments exhibiting self-sustained oscillations, including bowed strings, blown pipes, reeds, brasses, and singing. Intervals and consonance, musical scales, tuning and temperament. Basic room and auditorium acoustics. There are no formal prerequisites, but an ability to read music and having some previous musical experience will be very useful.

33-115 Physics for Future Presidents

Fall: 9 units

Countless topics of social and political importance are intimately related to science in general and physics in particular. Examples include energy production, global warming, radioactivity, terrorism, and space travel. This course aims to provide key bits of knowledge based on which such issues can be discussed in a meaningful way, i.e., on the level of arguments and not just vague beliefs. We will cover an unusually wide range of topics, including energy, heat, gravity, atoms, radioactivity, chain reactions, electricity, magnetism, waves, light, weather, and climate. No calculus or algebra will be required. The course is open for all students at CMU.

33-120 Science and Science Fiction

Summer: 9 units

We will view and critique the science content in a selection of science fiction films, spanning more than 100 years of cinematic history, and from sci-fi TV shows from the past 50+ years. Guided by selected readings from current scientific literature, and aided by order-of-magnitude estimates and careful calculations, we will ponder whether the films are showing things which may fall into one of the following categories: Science fiction at the time of production, but currently possible, due to recent breakthroughs. Possible, in principle, but beyond our current technology. Impossible by any science we know. Topics to be covered include the future of the technological society, the physics of Star Trek, the nature of space and time, extraterrestrial intelligence, robotics and artificial intelligence, biotechnology and more. Success of this course will depend upon class participation. Students will be expected to contribute to discussion of assigned readings and problems, and to give brief presentations in class on assigned films.

33-121 Physics I for Science Students

Fall and Spring: 12 units

This calculus-based course combines the basic principles of mechanics with some quantum physics and relativity to explain nature on both a microscopic and macroscopic scale. The course will build models to describe the universe based on a small number of fundamental physics principles. Some simple computer modeling will be done to develop insight into the solving of problems using Newton's laws. Topics covered will include vectors, momentum, force, gravitation, oscillations, energy, quantum physics, center of mass motion, rotation, angular momentum, statistical physics, and the laws of thermodynamics. No computer experience is needed. Examples illustrating basic principles being presented will be taken from physics, chemistry, and biology.
Corequisite: 21-120

33-122 Physics II for Biological Sciences and Chemistry Students

Fall and Spring: 9 units

This is the second course in the introductory physics sequence for chemistry and biological science majors. The course will consist of eight portions covering (1) electrostatics and dynamics, (2) electrical circuits, (3) magnetism, (4) waves, (5) optics, (6) diffusive motion, and (7) hydrostatic forces and flow. Emphasis will be put on the application of the underlying physical principles in the study of biology and chemistry.
Prerequisites: (21-120 and 33-121) or 33-151 or 33-141
Corequisites: 21-124 and 21-122

33-124 Introduction to Astronomy

Fall: 9 units

Astronomy continues to enjoy a golden age of exploration and discovery. This course presents a broad view of astronomy, straightforwardly descriptive and without any complex mathematics. The goal of the course is to encourage non-technical students to become scientifically literate and to appreciate new developments in the world of science, especially in the rapidly developing field of astronomy. Subjects covered include the solar system, stars, galaxies and the universe as a whole. The student should develop an appreciation of the ever-changing universe and our place within it. Computer laboratory exercises will be used to gain practical experience in astronomical techniques. In addition, small telescopes will be used to study the sky. This course is specifically geared toward non-science/engineering majors.

33-126 Astronomy Lab

Fall: 3 units

This course is the laboratory source in science and astronomy. It overviews the scientific method, teaches how to obtain knowledge from data and to develop physics-based models of natural phenomena, trains how to use astronomical instruments (telescope) to make observations and to explain these observations qualitatively, and explains how to apply of the state-of-the-art professional software to study our universe. Astronomy is one of the oldest fields of science with at least 3000 years of recorded history. On the astronomy side, major topics of this laboratory course include an overview of the Solar system and the Universe. The goals of the laboratory course are to expand the student's understanding of the motions of objects through the sky, to use astronomical techniques, such as telescope and simulated observations, and to obtain, analyze, and interpret data.

33-131 Matter and Interaction I

Fall: 12 units

A more challenging alternative to 33-111, Physics for Science Students I. Students with particularly strong physics backgrounds may volunteer for this course. Modeling of physical systems, including 3D computer modeling, with emphasis on atomic-level description and analysis of matter and its interactions. Momentum, numerical integration of Newton's laws, ball-and-spring model of solids, harmonic oscillator, energy, energy quantization, mass-energy equivalence, multiparticle systems, collisions, angular momentum including quantized angular momentum, kinetic theory of gases, statistical mechanics (temperature, entropy, and specific heat of the Einstein solid, Boltzmann factor).
Corequisite: 21-120

33-132 Matter and Interactions II

Spring: 12 units

A more challenging alternative to 33-112, Physics for Science Students II. Emphasis on atomic-level description and analysis of matter and its electric and magnetic interactions. Coulomb's law, polarization, electric field, plasmas, field of charge distributions, microscopic analysis of resistor and capacitor circuits, potential, macroscopic analysis of circuits, Gauss' law, magnetic field, atomic model of magnetism, Ampere's law, magnetic force, relativistic issues, magnetic induction with emphasis on non-Coulomb electric field, Maxwell's equations, electromagnetic radiation including its production and its effects on matter, re-radiation, interference. Computer modeling and visualization; desktop experiments.
Prerequisites: 33-131 and 21-120
Corequisite: 21-122

33-141 Physics I for Engineering Students

Fall and Spring: 12 units

This is a first semester, calculus-based introductory physics course. Basic principles of mechanics and thermodynamics are developed. Topics include vectors, displacement, velocity, acceleration, force, equilibrium, mass, Newton's laws, gravitation, work, energy, momentum, impulse, torque and angular momentum, temperature, heat, equations of state, thermodynamic processes, heat engines, refrigerators, first and second laws of thermodynamics, and the kinetic theory of gases.
Corequisite: 21-120

33-142 Physics II for Engineering and Physics Students

Fall and Spring: 12 units

This is the second half of a two-semester calculus-based introductory physics sequence for engineering and physics students. Two fifths of the course covers electricity, including electrostatics and electric fields, Gauss' law, electric potential, and simple circuits. Two fifths cover magnetism, including magnetic forces, magnetic fields, induction and electromagnetic radiation. One fifth of the course covers mechanical waves (including standing and traveling waves, superposition, and beats) and electromagnetic waves (including mode of propagation, speed, and other properties).
Prerequisites: (33-121 and 21-120) or 33-141 or 33-151
Corequisite: 21-122

33-151 Matter and Interactions I

Fall: 12 units

A more challenging alternative to 33-111, Physics for Science Students I. Students with particularly strong physics backgrounds may volunteer for this course. Modeling of physical systems, including 3D computer modeling, with emphasis on atomic-level description and analysis of matter and its interactions. Momentum, numerical integration of Newton's laws, ball-and-spring model of solids, harmonic oscillator, energy, energy quantization, mass-energy equivalence, multiparticle systems, collisions, angular momentum including quantized angular momentum, kinetic theory of gases, statistical mechanics (temperature, entropy, and specific heat of the Einstein solid, Boltzmann factor).
Prerequisite: 21-120
Corequisite: 21-122

33-152 Matter and Interactions II

Spring: 12 units

A more challenging alternative to 33-142, Physics II for Engineering and Physics Students. There is an emphasis on atomic-level description and analysis of matter and its electric and magnetic interactions. Topics include: Coulomb's law, polarization, electric field, plasmas, field of charge distributions, microscopic analysis of resistor and capacitor circuits, potential, macroscopic analysis of circuits, Gauss' law, magnetic field, atomic model of magnetism, Ampere's law, magnetic force, relativistic issues, magnetic induction with emphasis on non-Coulomb electric field, Maxwell's equations, electromagnetic radiation including its production and its effects on matter, re-radiation, interference. There will also be computer modeling, visualization and desktop experiments.

Prerequisites: 21-122 and 33-151

Corequisite: 21-259

33-201 Physics Sophomore Colloquium I

Fall: 2 units

This course (together with 33-202) is designed to give students an overview of the field of Physics and to help students make knowledgeable choices in both their academic and professional careers. We discuss several of the sub-fields of Physics in order to give students an understanding of the types of activities, from research to industrial applications, in each. Over the two semesters, we typically discuss six subfields in some detail with the goal of providing a minimal literacy in the relevant concepts and language. The course consists of one classroom lecture per week plus one hour per week of reading and/or problem solving.

33-202 Physics Sophomore Colloquium II

Spring: 2 units

Continuation of 33-201.

33-211 Physics III: Modern Essentials

Fall and Spring: 10 units

Physics III is primarily for third-semester students of physics, including all physics majors, but is open to any qualified student who wants an introduction to the physics of the 20th century. The course will have a strong component of Special Relativity, dealing with kinematics and dynamics, but not electricity and magnetism. (See 33-213 description.) It will introduce students to a conceptual theory, which is mathematically simple but (initially) non-intuitive. The course also provides a broad exposure to quantum phenomena and early quantum theory without getting overly mathematical. It leads into the more formal Quantum Physics course (33-234).

Prerequisites: 33-112 or 33-107 or 33-132

33-213 Mini-Course in Special Relativity

Fall and Spring: 4 units

This course spans the first six weeks of 33-211, Physics III: Modern Essentials. It treats the Mechanics aspects of Special Relativity, including topics such as simultaneity, the Lorentz transformation, time dilation, length contraction, space-time geometry, resolving some famous puzzles, and the momentum, mass, and energy relations. The Electricity and Magnetism portions of the subject are deferred until the junior/senior courses in E&M (33-338/33-339).

Prerequisites: 33-112 or 33-107 or 33-132

33-224 Stars, Galaxies and the Universe

Fall: 9 units

The study of astronomy has blossomed over the past few decades as a result of new ground-based and space-based telescopes, and with the advantage of fast computers for analysis of the huge quantities of data. As our astronomical horizon expands, we are still able to use the laws of physics to make sense of it all. This course is for students who want to understand the basic concepts in astronomy and what drives astronomical objects and the universe. The course emphasizes the application of a few physical principles to a variety of astronomical settings, from stars to galaxies to the structure and evolution of the universe. Introductory classical physics is required, but modern physics will be introduced as needed in the course. The course is intended for science and engineering majors as well as students in other disciplines with good technical backgrounds. Computer lab exercises will be used to gain practical experience in astronomical techniques. In addition, small telescopes are available for personal sign-out for those who would like to use them, and outdoor observing sessions will be organized as weather permits.

Prerequisites: 33-106 or 33-111 or 33-131

33-225 Quantum Physics and Structure of Matter

Fall: 9 units

This course introduces the basic theory used to describe the microscopic world of electrons, atoms, and photons. The duality between wave-like and particle-like phenomena is introduced along with the deBroglie relations which link them. We develop a wave description appropriate for quanta which are partially localized and discuss the interpretation of these wavefunctions. The wave equation of quantum mechanics is developed and applied to the hydrogen atom from which we extrapolate the structure of the Periodic Table. Other materials-related applications are developed, for example, Boltzmann and quantum statistics and properties of electrons in crystals. This course is intended primarily for non-physics majors who have not taken 33-211.

Prerequisites: 33-107 or 33-112 or 33-132

33-228 Electronics I

Spring: 10 units

An introductory laboratory and lecture course with emphasis on elementary circuit analysis, design, and testing. We start by introducing basic circuit elements and study the responses of combinations to DC and AC excitations. We then take up transistors and learn about biasing and the behavior of amplifier circuits. The many uses of operational amplifiers are examined and analyzed; general features of feedback systems are introduced in this context. Complex functions are used to analyze all of the above linear systems. Finally, we examine and build some simple digital integrated circuits.

Prerequisites: 33-107 or 33-112 or 33-132

33-231 Physical Analysis

Fall: 10 units

This course aims to develop analytical skills and mathematical modeling skills across a broad spectrum of physical phenomena, stressing analogies in behavior of a wide variety of systems. Specific topics include dimensional analysis and scaling in physical phenomena, exponential growth and decay, the harmonic oscillator with damping and driving forces, linear approximations of nonlinear systems, coupled oscillators, and wave motion. Necessary mathematical techniques, including differential equations, complex exponential functions, matrix algebra, and elementary Fourier series, are introduced as needed.

Prerequisites: 21-122 and (33-107 or 33-112 or 33-132)

33-232 Mathematical Methods of Physics

Spring: 10 units

This course introduces, in the context of physical systems, a variety of mathematical tools and techniques that will be needed for later courses in the physics curriculum. Topics will include, linear algebra, vector calculus with physical application, Fourier series and integrals, partial differential equations and boundary value problems. The techniques taught here are useful in more advanced courses such as Physical Mechanics, Electricity and Magnetism, and Advanced Quantum Physics.

Prerequisite: 33-231

33-234 Quantum Physics

Spring: 10 units

An introduction to the fundamental principles and applications of quantum physics. A brief review of the experimental basis for quantization motivates the development of the Schrodinger wave equation. Several unbound and bound problems are treated in one dimension. The properties of angular momentum are developed and applied to central potentials in three dimensions. The one electron atom is then treated. Properties of collections of indistinguishable particles are developed allowing an understanding of the structure of the Periodic Table of elements. A variety of mathematical tools are introduced as needed.

Prerequisite: 33-211

33-241 Introduction to Computational Physics

Fall: 9 units

The course emphasizes the formulation of physical problems for machine computation with exploration of alternative numerical methods. Work will be done on a range of computers from workstations to high performance computing platforms. Examples are drawn from Physics I and II, and Experimental Physics, as well as concurrent physics courses.

Prerequisites: 15-112 and 21-122 and 33-104 and (33-107 or 33-112 or 33-132)

33-301 Physics Upperclass Colloquium I

Fall: 1 unit

Upperclass Physics majors meet together for 1 hour a week to hear discussions on current physics research from faculty, undergraduate and graduate students, and outside speakers. Other topics of interest such as application to graduate school, areas of industrial research and job opportunities are also be presented.

33-302 Physics Upperclass Colloquium II

Spring: 1 unit

Continuation of 33-301.

33-331 Physical Mechanics I

Fall: 10 units

Fundamental concepts of classical mechanics. Conservation laws, momentum, energy, angular momentum, Lagrange's and Hamilton's equations, motion under a central force, scattering, cross section, and systems of particles.

Prerequisites: 21-259 and 33-232

33-332 Physical Mechanics II

Spring: 10 units

This is the second semester of a two-semester course on classical mechanics. The course will use the tools developed in 33-331 to examine motion in non-inertial reference frames; in particular, rotating frames. This then leads to the development of general rigid body motion, Euler's Equations. Finally, the course will cover coupled oscillations with particular emphasis on normal modes.

Prerequisite: 33-331

33-338 Intermediate Electricity and Magnetism I

Fall: 10 units

This course includes the basic concepts of electro- and magnetostatics. In electrostatics, topics include the electric field and potential for typical configurations, work and energy considerations, the method of images and solutions of Laplace's Equation, multipole expansions, and electrostatics in the presence of matter. In magnetostatics, the magnetic field and vector potential, magnetostatics in the presence of matter, properties of dia-, para- and ferromagnetic materials are developed.

Prerequisites: 21-259 and 33-232

33-339 Intermediate Electricity and Magnetism II

Spring: 10 units

This course focuses on electro- and magnetodynamics. Topics include Faraday's Law of induction, electromagnetic field momentum and energy, Maxwell's equations and electromagnetic waves including plane waves, waves in non-conducting and conducting media, reflection and refraction of waves, and guided waves. Electromagnetic radiation theory includes generation and characteristics of electric and magnetic dipole radiation. The Special Theory of Relativity is applied to electrodynamic: electric and magnetic fields in different reference frames, Lorentz transformations, four-vectors, invariants, and applications to particle mechanics.

Prerequisite: 33-338

33-340 Modern Physics Laboratory

Spring: 10 units

Emphasis is on hands-on experience observing important physical phenomena in the lab, advancing the student's experimental skills, developing sophisticated data analysis techniques, writing thorough reports, and improving verbal communication through several oral progress reports given during the semester and a comprehensive oral report on one experiment. Students perform three experiments which are drawn from the areas of atomic, condensed matter, classical, and nuclear and particle physics. Those currently available are the following: Zeeman effect, light scattering, optical pumping, thermal lensing, Raman scattering, chaos, magnetic susceptibility, nuclear magnetic resonance, electron spin resonance, X-ray diffraction, Mössbauer effect, neutron activation of radioactive nuclides, Compton scattering, and cosmic ray muons.

Prerequisites: 33-234 and (33-331 or 33-338 or 33-341)

33-341 Thermal Physics I

Fall: 10 units

The three laws of classical thermodynamics, which deal with the existence of state functions for energy and entropy and the entropy at the absolute zero of temperature, are developed along phenomenological lines. Elementary statistical mechanics is then introduced via the canonical ensemble to understand the interpretation of entropy in terms of probability and to calculate some thermodynamic quantities from simple models. These laws are applied to deduce relationships among heat capacities and other measurable quantities and then are generalized to open systems and their various auxiliary thermodynamic potentials; transformations between potentials are developed. Criteria for equilibrium of multicomponent systems are developed and applied to phase transformations and chemical reactions. Models of solutions are obtained by using statistical mechanics and are applied to deduce simple phase diagrams for ideal and regular solutions. The concept of thermodynamic stability is then introduced and illustrated in the context of phase transformations.

Prerequisites: 33-232 and 33-234

33-342 Thermal Physics II

Spring: 10 units

This course begins with a more systematic development of formal probability theory, with emphasis on generating functions, probability density functions and asymptotic approximations. Examples are taken from games of chance, geometric probabilities and radioactive decay. The connections between the ensembles of statistical mechanics (microcanonical, canonical and grand canonical) with the various thermodynamic potentials is developed for single component and multicomponent systems. Fermi-Dirac and Bose-Einstein statistics are reviewed. These principles are then applied to applications such as electronic specific heats, Einstein condensation, chemical reactions, phase transformations, mean field theories, binary phase diagrams, paramagnetism, ferromagnetism, defects, semiconductors and fluctuation phenomena.

Prerequisite: 33-341

33-350 Undergraduate Research

Fall and Spring

The student undertakes a project of interest under the supervision of a faculty member. May include research done in a research lab, extending the capabilities of a teaching lab, or a theoretical or computational physics project. The student experiences the less structured atmosphere of a research program where there is much room for independent initiative. A list of research projects is available. The student must contact the Assistant Head for the Undergraduate Affairs before registering so that student project pairings can be set. Reports on results are required at end of semester.

33-353 Intermediate Optics

Fall: 12 units

Offer alternative years. Geometrical optics: reflection and refraction, mirrors, prisms, lenses, apertures and stops, simple optical instruments, fiber optics. Scalar wave optics: wave properties of light, interference, coherence, interferometry, Huygens-Fresnel principle, Fraunhofer diffraction, resolution of optical instruments, Fourier optics, Fresnel diffraction. Laser beam optics: Gaussian beams. Vector wave optics: electromagnetic waves at dielectric interfaces, polarized light. The course will use complex exponential representations of electromagnetic waves.

Prerequisites: 33-107 or 33-112 or 33-132

33-355 Nanoscience and Nanotechnology

Fall: 9 units

Offered alternative years. This course will explore the underlying science behind nanotechnology, the tools used to create and characterize nanostructures, and potential applications of such devices. Material will be presented on a level intended for upper-level science and engineering students. The course will start with a brief review of the physical principles of electric fields and forces, the nature of chemical bonds, the interaction of light with matter, and elastic deformation of solids. Characterization using electron microscopy, scanning probe methods, and spectroscopic techniques will then be described in detail. Fabrication using top-down and bottom-up methods will be discussed, contrasting these approaches and providing examples of each. Nanotechnology methods will be compared with those used in the modern micro-electronics industry. Finally, examples of nanoscale components and systems will be described, including quantum dots, self-assembled monolayers, molecular computing, and others. Stand-alone laboratory exercises will be included as an important element of the course. These will focus on the use of scanning probe methods to study the nm-scale structure and atomic forces involved in various nanostructures. Students will sign up for these laboratory sessions and perform the exercises under the supervision of a teaching assistant. In addition to the prerequisites, students should have taken a prior laboratory course in a science or engineering department and should have some familiarity with differential equations at an elementary level.

Prerequisites: 33-107 or 33-132 or 33-112

33-398 Special Topics

Fall: 9 units

The description of most all physical systems relies on the concept of a manifold. In addition to the space-time manifold, which plays the role of the stage upon which the dynamics plays out, many systems involve target spaces which are manifolds. These target spaces are typically Lie Groups. A classic example of such a system is the rigid rotator, where every configuration of the system is a point on the manifold which defines the group of rotations. The purpose of this class will be to learn the basics of differential geometry and apply these ideas to physical systems. Topics will include Hamiltonian dynamics, fluid mechanics as well as gauge theories. Requirements: Knowledge of Linear Algebra. No prior knowledge of group theory will be expected.

Prerequisites: (33-231 or 21-260) and 21-341

33-441 Introduction to BioPhysics

Fall: 10 units

This intermediate level course is primarily offered to Physics and Biology undergrads (junior/senior) and provides a modern view of molecular and cellular biology as seen from the perspective of physics, and quantified through the analytical tools of physics. This course will not review experimental biophysical techniques (which are covered, e.g., in 03-871). Rather, physicists will learn what sets "bio" apart from the remainder of the Physics world and how the apparent dilemma that the existence of life represents to classical thermodynamics is reconciled. They also will learn the nomenclature used in molecular biology. In turn, biologists will obtain (a glimpse of) what quantitative tools can achieve beyond the mere collecting and archiving of facts in a universe of observations: By devising models, non-obvious quantitative predictions are derived which can be experimentally tested and may lead to threads that connect vastly different, apparently unrelated phenomena. One major goal is then to merge the two areas, physics an biology, in a unified perspective.

Prerequisites: 03-121 and (33-112 or 33-107 or 33-132)

33-444 Introduction to Nuclear and Particle Physics

Spring: 9 units

Description of our understanding of nuclei, elementary particles, and quarks, with equal emphasis on the nuclear and particle aspects of sub-atomic matter. We discuss the physics of accelerators, and how particle interactions with matter lead to various kinds of detector instrumentation. Then we discuss methods for measuring sub-atomic structure, symmetries and conservation laws, and the electromagnetic, weak, and strong interactions. We examine the quark model of the mesons and baryons, as well as several models of the atomic nucleus.

Prerequisites: 33-234 and 33-338

33-445 Adv Quantum Physics I

Fall: 9 units

Mathematics of quantum theory, linear algebra and Hilbert spaces; review of classical mechanics; problems with classical mechanics; postulates of quantum theory; one dimensional applications; the harmonic oscillator; uncertainty relations; systems with N degrees of freedom, multi-particle states, identical particles; approximation methods.

Prerequisite: 33-234

Corequisite: 33-331

33-446 Advanced Quantum Physics II

Spring: 9 units

Classical symmetries; quantum symmetries; rotations and angular momentum; spin; addition of angular momentum; the hydrogen atom; quantum "paradoxes" and Bell's theorem; applications.

Prerequisite: 33-445

33-448 Introduction to Solid State Physics

Spring: 9 units

This course gives a quantitative description of crystal lattices, common crystal structures obtained by adding a basis of atoms to the lattice, and the definition and properties of the reciprocal lattice. Diffraction measurements are studied as tools to quantify crystal lattices, including Bragg's law and structure factors. Diffraction from amorphous substances and liquids is also introduced. The various types of atomic bonding, e.g., Van der Waals, metallic, ionic, covalent and hydrogen are surveyed. Binding energies of some crystalline structures are calculated. Models of crystal binding are generalized to include dynamics, first for classical lattice vibrations and then for quantized lattice vibrations known as phonons. These concepts are used to calculate the heat capacities of insulating crystals, to introduce the concept of density of states, and to discuss phonon scattering.

The band theory of solids is developed, starting with the free electron model of a metal and culminating with the properties of conductors and semiconductors. Magnetic phenomena such as paramagnetism and the mean field theory of ferromagnetism are covered to the extent that time permits.

Prerequisites: 33-341 and (33-225 or 33-234)

33-451 Senior Research

Fall and Spring

Open to all senior physics majors. May include research done in a research lab, extending the capabilities of a teaching lab, or a theoretical or computational physics project. The student experiences the less structured atmosphere of a research program where there is much room for independent initiative. Modern Physics Laboratory, 33-340, should precede this course, though it is not required. A list of research projects is available. The student must contact a faculty member and/or the Assistant Head for the Undergraduate Affairs before registering so that student project pairings can be set. Reports on results are required at end of semester.

33-456 Advanced Computational Physics

Spring: 9 units

This course emphasizes application of practical numerical techniques to the types of problems that are encountered by practicing physicists. The student will be expected to understand the principles behind numerical methods such as SVD decomposition, chi-squared minimization, and Fast Fourier Transforms and Monte Carlo simulation of experiments. Applications will include data analysis and eigenvalue problems. Emphasis will be placed on the ability to implement complex algorithms accurately by devising methods of checking results and debugging code. The students will be expected to become proficient in Fortran or C programming.

Prerequisite: 33-241

33-466 Extragalactic Astrophysics and Cosmology

Spring: 9 units

Starting from the expanding universe of galaxies, this course lays out the structure of the universe from the Local Group of galaxies to the largest structures observed. The observational pinnacle of the Big Bang theory, the microwave background radiation, is shown to provide us with many clues to conditions in the early universe and to the parameters which control the expansion and fate of the universe. Current theories for the development of galaxies and clusters of galaxies are outlined in terms of our current understanding of dark matter. Observational cosmology continues to enjoy a golden era of discovery and the latest observational results will be interpreted in terms of the basic cosmological parameters.

Prerequisites: 33-224 and 33-234

33-467 Astrophysics of Stars and the Galaxy

Fall: 9 units

The physics of stars is introduced from first principles, leading from star formation to nuclear fusion to late stellar evolution and the end points of stars: white dwarfs, neutron stars and black holes. The theory of stellar structure and evolution is elegant and impressively powerful, bringing together all branches of physics to predict the life cycles of the stars. The basic physical processes in the interstellar medium will also be described, and the role of multi-wavelength astronomy will be used to illustrate our understanding of the structure of the Milky Way Galaxy, from the massive black hole at the center to the halo of dark matter which encompasses it.

Prerequisites: 33-224 and 33-234

Corequisite: 33-341

33-499 Supervised Reading

Fall and Spring

The student explores a certain area of advanced physics under the supervision of a faculty member. The student must contact a faculty member and the Assistant Head for Undergraduate Affairs before registering.

33-650 General Relativity

Fall: 9 units

General Relativity is the classical theory of gravity. It is widely recognized as a beautiful theory - equating gravity and the geometry of spacetime leads to a profound conceptual change in the way we regard the universe. The predictions of the theory are relevant to systems as varied as high precision measurements of the earth's gravitational field or the strongly curved space-times around black holes. In this course, we will gradually develop an understanding of the geometries which are the solutions of the Einstein equation, with an emphasis on their relevance to physical situations. We will motivate the theory step by step and eventually introduce the Einstein equation itself. Typical Textbook(s): "Gravity, An Introduction to Einstein's General Relativity" by James Hartle.

Prerequisites: 33-211 and 33-339

33-658 Quantum Computation and Quantum Information Theory

Spring: 10 units

This course, taught in collaboration with the Computer Science Department, provides an overview of recent developments in quantum computation and quantum information theory. The topics include: an introduction to quantum mechanics, quantum channels, both ideal and noisy, quantum cryptography, an introduction to computational complexity, Shor's factorization algorithm, Grover's search algorithm, and proposals for the physical realization of quantum devices, such as correlated photons, ions in traps, and nuclear magnetic resonance. The course includes a weekly seminar. Typical Textbook(s): "Quantum Computation and Quantum Information" by Nielsen and Chuang.

33-755 Quantum Mechanics I

Fall: 12 units

This course introduces fundamental concepts of quantum mechanics. Applications are made to quantum computing, the harmonic oscillator, the hydrogen atom, electron spin and addition of angular momentum. 3hrs. lecture. Typical Text: Cohen-Tannoudji Quantum Mechanics, volume 1.

Prerequisite: 33-759

33-756 Quantum Mechanics II

Spring: 12 units

This course focuses on qualitative and approximation methods in quantum mechanics, including time-independent and time-dependent perturbation theory, scattering and semiclassical methods. Applications are made to atomic, molecular and solid matter. Systems of identical particles are treated including many electron atoms and the Fermi gas. Prerequisite: 33-755, Quantum Mechanics I; 33-759 Theoretical Physics. 3 hrs. lecture. Typical Text: Cohen-Tannoudji Quantum Mechanics, volume 2.

33-758 Quantum Computation and Quantum Information Theory

Spring: 12 units

This course, taught in collaboration with the Computer Science Department, provides an overview of recent developments in quantum computation and quantum information theory. The topics include: an introduction to quantum mechanics, quantum channels, both ideal and noisy, quantum cryptography, an introduction to computational complexity, Shor's factorization algorithm, Grover's search algorithm, and proposals for the physical realization of quantum devices, such as correlated photons, ions in traps, and nuclear magnetic resonance. The textbook is Nielsen and Chuang, Quantum Computation and Quantum Information. 3 hrs. lecture plus weekly seminar. A 10 unit version of the course, 33-658, does not include the seminar.

33-759 Introduction to Mathematical Physics I

Fall: 12 units

This course is an introduction to methods of mathematical analysis used in solving physical problems. Emphasis is placed both upon the generality of the methods, through a variety of sample problems, and upon their underlying principles. Topics normally covered include matrix algebra (normal modes, diagonalization, symmetry properties), complex variables and analytic functions, differential equations (Laplace's equation and separation of variables, special functions and their analytic properties), orthogonal systems of functions. 3 hrs. lecture and recitation. Typical Text: G. Arfken, Mathematical Methods for Physicists.

33-761 Classical Electrodynamics I

Fall: 12 units

This course deals with the static and dynamic properties of the electromagnetic field as described by Maxwell's equations. Among the topics emphasized are solutions of Laplace's, Poisson's and wave equations, effects of boundaries, Green's functions, multipole expansions, emission and propagation of electromagnetic radiation and the response of dielectrics, metals, magnetizable bodies to fields. 3 hrs. lecture. Typical Text: Jackson, Classical Electrodynamics, 2nd Ed.

33-762 Classical Electrodynamics II

Spring: 12 units

The applications of electromagnetic theory to various physical systems is the main emphasis of this course. The topics discussed include the theory of wave guides, scattering of electromagnetic waves, index of refraction, special relativity and foundation of optics. 3 hrs. lecture. Typical Text: Jackson, Classical Electrodynamics. 2nd Ed.

33-765 Statistical Mechanics

Spring: 12 units

This course develops the methods of statistical mechanics and uses them to calculate observable properties of systems in thermodynamic equilibrium. Topics treated include the principles of classical thermodynamics, canonical and grand canonical ensembles for classical and quantum mechanical systems, partition functions and statistical thermodynamics, fluctuations, ideal gases of quanta, atoms and polyatomic molecules, degeneracy of Fermi and Bose gases, chemical equilibrium, ideal paramagnetics and introduction to simple interacting systems. 3 hrs. lecture, 1 hr. recitation. Typical Texts: Reif, Statistical and Thermal Physics; Pathria, Statistical Mechanics.

33-767 Biophysics: From Basic Concepts to Current Research

Spring: 12 units

Biological Physics aims to apply the principles of physics and the methods of mathematical analysis and computer modeling to understand how biological systems work. This course serves as an introduction into this discipline, suitable as a one-semester course for students not necessarily specializing in this area. It will both provide the necessary general concepts, as well as follow some selected topics up to the current frontier of research. Prerequisite: 33-765 or permission of instructor. Typical text: P. Nelson, Biological Physics, as well as selected original papers.

33-769 Quantum Mechanics III: Many Body and Relativistic Systems

Fall: 12 units

The first main theme of this course is quantum mechanics applied to selected many-body problems in atomic, nuclear and condensed matter physics. The second main theme is relativistic quantum mechanics. Creation and annihilation operators are introduced and used to discuss Hartree-Fock theory as well as electromagnetic radiation. The Dirac equation is introduced and applied to the hydrogen atom. Prerequisite: 33-756, 33-761. 3 hrs. lecture

33-770 Field Theory I

Fall: 12 units

This course gives systematic studies of the relativistic field theories. Topics included are canonical quantization of fields, LSZ reduction formula, Feynman diagram techniques, application to quantum electrodynamics and the discussion of the methods of renormalization. Prerequisite: 33-769. 3 hrs. lecture.

33-771 Field Theory II

All Semesters: 12 units

Missing Course Description - please contact the teaching department.

33-777 Introductory Astrophysics

Fall: 12 units

Introductory Astrophysics will explore the applications of physics to the following areas: (i) celestial mechanics and dynamics, (ii) the physics of solar system objects, (iii) the structure, formation and evolution of stars and galaxies, (iv) the large scale structure of the universe of galaxies, (v) cosmology: the origin, evolution and fate of the universe.

33-779 Introduction to Nuclear and Particle Physics

Fall: 12 units

An introduction to the physics of atomic nuclei and elementary particles. This course is suitable as a one-semester course for students not specializing in this area and also provides an introduction to further work in 33-780, 33-781. Topics included are symmetry principles of strong and weak interactions, quark model, classification of particles and nuclear forces. Prerequisite: 33-769 (or con-currently). 3 hrs. lecture. Typical Text: Perkins, Introduction to High Energy Physics, plus notes and reading.

33-780 Nuclear and Particle Physics II

Spring: 12 units

This course covers the phenomenology of weak interactions, parton model for the deep inelastic scattering, and introduction to gauge theories of weak and electromagnetic interactions. Various topics of current interest in particle physics will also be included. Prerequisite: 33-779, 33-770 (or concurrently). 3 hrs. lecture.

33-783 Solid State Physics

Fall: 12 units

This course is designed to give advanced graduate students a fundamental knowledge of the microscopic properties of solids in terms of molecular and atomic theory, crystal structures, x-ray diffraction of crystals and crystal defects, lattice vibration and thermal properties of crystals; free-electron model, energy bands, electrical conduction and magnetism. Prerequisite: 33-756. 3 hrs. lecture. Typical Text: Ashcroft and Mermin, Solid State Physics. Prerequisite: 33-756

Psychology Courses

85-102 Introduction to Psychology

Fall and Summer: 9 units

This course examines major areas of scientific psychology in some depth, the attempt being to develop basic models of our behavior and thought that explain wide areas of our functioning. The primary focus is on the areas of neural and motivational control of behavior, memory and thought, social interaction, and psychological development. Specific topics within these areas include brain function, motivational control systems, learning, cognitive and perceptual information processing, problem solving, obedience and conformity, social interaction, emotion, attitude consistency and change, how our social, cognitive and language functions develop, the importance of childhood to adult functioning, and psychopathology. In addition to the lecture, the course includes a weekly recitation section meeting and weekly short WEB-based laboratory experiences in which students get to perform actual experiments, interpret real data, and experience many psychological phenomena.

85-198 Research Training: Psychology

Fall and Spring: 9 units

See www.hss.cmu.edu/aac and click on (forms and guides informational handout page) then click on current freshman-sophomore research training courses for listing of research training course descriptions.

Course Website: <http://www.hss.cmu.edu/aac>**85-211 Cognitive Psychology**

Fall and Spring: 9 units

How do people perceive, learn, remember, and think? This course will consider perception, language, attention, learning, memory, reasoning, and decision making. Experimental findings and formal models will be discussed in each part of the course.

85-213 Human Information Processing and Artificial Intelligence

Fall: 9 units

This class will review various results in cognitive psychology (attention, perception, memory, problem solving, language) and use of artificial intelligence techniques to simulate cognitive processes.

Prerequisites: 15-122 or 15-150

85-219 Biological Foundations of Behavior

Fall: 9 units

This course will provide students with a general introduction to the underlying biological principles and mechanisms which give rise to complex human cognitive, perceptual and emotional behavior. Topics to be covered include: the anatomical structure of nerve cells and how they communicate, properties of brain organization and function, processing in sensory and motor systems, biological characteristics of human cognition, and neural and hormonal influences on health and emotion. This course will focus on how emerging methods and approaches are beginning to make it possible for psychologists, computer scientists, and biologists to gain an integrated understanding of complex behavior.

85-221 Principles of Child Development

Fall and Spring: 9 units

This course is about normal development from conception through adolescence. Topics include physical, perceptual, cognitive, emotional and social development. Students will learn facts about children at various points in development, theories about how development works, and research methods for studying development in infants and children. Students will be encouraged to relate the facts, theories and methods of developmental psychology to everyday problems, social issues and real world concerns.

85-241 Social Psychology

Fall and Spring: 9 units

The focus of this course will be on how peoples behavior, feelings and thoughts are influenced or determined by their social environment. The course will begin with lectures and readings on how social psychologists go about studying social behavior. Next, various topics on which social psychologists have done research will be covered. These topics will include: person perception, prejudice and discrimination, the nature of attitudes and how attitudes are formed and changed, interpersonal attraction, conformity, compliance, altruism, aggression, group behavior, and applications of psychology to problems in health care, law, politics, and the environment. Through readings and lectures on these topics, students will also be exposed to social psychological theories.

85-251 Personality

Intermittent: 9 units

The primary purpose of personality psychology is to understand human uniqueness—how and why it is that one person differs from others, in terms of the ways he or she thinks, feels, and acts. Students in the course will be exposed to several broad theoretical perspectives, each of which attempts to capture and understand the origins and consequences of individual distinctiveness from a slightly different vantage point. Included among these approaches are the dispositional, psychoanalytic, learning, phenomenological, and cognitive self regulation perspectives. This is a survey course and is intended to provide students with a broad background of theory and research in the area. Class meetings consist primarily of lecture, but there is some discussion too. In addition, classroom exercises will allow students to test their own personalities.

85-261 Abnormal Psychology

Fall and Spring: 9 units

The study of psychopathology is not an exact science; nor are there many clear-cut parameters with which to differentiate "normal" and "abnormal" behavior. This course will focus on learning about and understanding the range of behaviors which fall within the province of "abnormal" psychology. Its approach will be descriptive, empirical, theoretical and conceptual. Students will examine definitions of "abnormality" in an historical and contemporary context, explore issues relevant to diagnosis and patient care, be introduced to various psychological diagnostic categories, and develop an appreciation of the range of treatments for these disorders.

85-281 Introduction to Clinical Psychology

Spring: 9 units

This course is designed to introduce students to a wide variety of concepts in the area of clinical psychology. We will explore clinical psychology in an historical perspective, ethics related to the practice of psychology, and various theories of psychotherapy (Including psychoanalytic, psychodynamic, existential, and cognitive behavioral). Also, we will look at group theories underlying group therapy and family/systems therapy.

Prerequisites: 85-251 or 85-261

85-310 Research Methods in Cognitive Psychology

Fall and Spring: 9 units

This is a course in which students develop the research skills associated with cognitive psychology and cognitive science. Students learn how to design and conduct experiments, and analyze and interpret the data they collect. The course covers a variety of experimental designs, e.g., factorial, Latin Squares. Analyses of response times, qualitative data, and signal detection are also covered. Cognitive modeling will also be discussed. Topics include mental imagery, memory, and perception. The class format consists of lectures, discussions and student presentations.

Prerequisites: (36-309 and 85-211) or (85-213 and 36-309)

85-314 Cognitive Neuroscience Research Methods

Intermittent: 9 units

This is a hands-on laboratory course designed to foster basic skills in the empirical approaches used in cognitive neuroscience research. Students will learn how to design experiments using both correlational and interference methods, learn basic analytical approaches and how to formally present empirical results. Topics will include MRI (structural and functional), electrophysiology, brain stimulation methods, neuropsychological approaches, experimental design (e.g., event-related vs. blocked trials) and basic data analysis. You must have taken 36-309 previously. A background in basic neurobiology, such as 85-219, and some experience with Matlab are encouraged but not required.

Prerequisite: 36-309

85-320 Research Methods in Developmental Psychology

Fall and Spring: 9 units

This is a laboratory course, in which the student will have direct experience working with children, as well as writing research reports and designing and critiquing research in child development. The purpose of the course is to develop research expertise that will assist the student both in carrying out research and in evaluating the research of others. Special emphasis will be given to the unique methodological problems associated with the study of development.

Prerequisites: 85-221 and 36-309

85-330 Analytic Research Methods

Intermittent: 9 units

This class will teach students how to apply six major non-experimental research methods used in analytic behavioral analysis. Protocol Analysis. This method is used to study patterns and changes in problem-solving and their matches to theoretical models, including computational models. Corpus Analysis. This method is used to isolate patterns of behavioral and communication usage and change, as revealed through the study of the world-wide web and large computerized databases such as CHILDES, TalkBank, or the British National Corpus. Tools here include text searches and data-mining. Conversation Analysis. This is a microanalytic method used to examine sequencing, repair, and orientation in closely transcribed recordings of spoken interactions, as made available through systems such as the CABank database, as well as recorded programs on YouTube and elsewhere. Coding Systems. This approach seeks to capture interactional and behavioral structures in writing, teaching, interview, and other interactions. Here, there will be a special emphasis on the coding of instructional interactions. Gesture Analysis. This microanalytic method seeks to track patterns in gestural and nonverbal communication, often in association with spoken messages. Profile Analysis. This approach studies differences across learners at various ages and ability levels and group differences involving aphasia, autism, stuttering, dementia, and other individual differences. Students will work with data already available from previous studies, and will also learn to collect their own new datasets. Although the data being examined have been generated through naturalistic processes, they can be analyzed quantitatively using time-series analyses, non-parametric statistics, error matrices, and neural network simulations. In these various analyses, we will also consider how behavioral patterns are shape

Prerequisites: 85-320 or 85-340 or 85-310

85-340 Research Methods in Social Psychology

Fall and Spring: 9 units

This course is designed to provide students with the necessary knowledge to evaluate research, make transitions between theory and the operations that test the theory, and to design and carry out original research. Topics will include the nature of proof and causal inference, manipulation of independent variables, measurement of dependent variables, questionnaire design, experimental, and quasi-experimental, design and ethical issues involved in doing research. Survey, observational and experimental techniques as applied in both field and laboratory settings will be covered. Students will be expected to criticize completed research. They are also expected to design measures and complete their own original studies. During the course of the semester students will also be expected to design and carry out an original research project as well.

Prerequisites: (85-251 and 36-309) or (36-309 and 85-241) or (85-251 and 36-202) or (36-202 and 85-241)

85-341 Organizational Communication

Spring: 9 units

Much of the work in groups and organizations consists of communication. You communicate to get information that will be the basis of decisions, to provide a vision for the people who work for and with you, to coordinate activity, and to sell yourself and your work. The goal of this course is to identify sources of communication problems within an organization and ways to overcome them. To do this requires that we know how communication normally works, what parts are difficult, and how to fix it when it goes wrong. The focus of this course is on providing you with a broad understanding of the way communication operates within dyads, work groups, and organizations. This course is not a practicum in public speaking or writing, although you will get some experience writing, speaking, and managing impressions. Rather the intent is to give you theoretical and empirical underpinnings for the communication you will undoubtedly do when you return to work. Readings come from both the research and the managerial literatures. Among the topics considered are managerial communication, persuasion and conformity, self presentation and person perception, social networks. Cases and group projects give you an opportunity to apply what you've learned.

Prerequisites: 36-201 or 36-225 or 36-247 or 36-207 or 36-217 or 36-220 or 70-207

85-350 Psychology of Prejudice

Spring: 9 units

This course is devoted to the study of both traditional and more modern forms of prejudice and discrimination and the psychological processes that can arise from categorizations and stereotyping. The class provides an overview of the cognitive and emotional underpinnings of prejudice and discrimination as it pertains to many forms of inequality. The psychological theories underlying these behaviors will be examined as well as their impact on the lives of stigmatized individuals. Its goal is to examine a number of social differences and understand how prejudice can impact many areas of society. In addition to the traditional forms of prejudice based on such things as race, gender and age; other inequalities that result from less traditional groupings such as social class, appearance, and disability and will be explored. Research on issues of social identity, intergroup relations and the reduction of prejudice will be examined through readings and class activities.

Prerequisite: 85-241

85-352 Evolutionary Psychology

Intermittent: 9 units

This course will cover both the fundamentals of evolutionary psychology, including the theories of natural and sexual selection, with the overarching aim of providing an overview of the field at an advanced level. We will examine the relevance of evolutionary thinking to a range of psychological phenomena including problems of survival, long-term mating strategies, short-term sexual strategies, parenting, kinship, cooperative alliances, aggression and warfare, conflict between the sexes, and prestige, status, and social dominance. We will also examine evolutionary approaches to sensation and perception, development, consciousness, cognition, language, and abnormal behavior. Juniors and Seniors only or permission of instructor. Pre req: 85-102, 85-211, 85-221, 85-241 or 85-251

Prerequisites: 85-251 or 85-241 or 85-221 or 85-102 or 85-211

85-354 Infant Language Development

Intermittent: 9 units

While adults struggle to learn languages, almost all infants acquire language with seemingly little effort. This course examines infants' learning abilities and language milestones with a focus on several different theoretical accounts of language development, and the way empirical data can be used to assess those theories. The course is reading intensive, and evaluation will be based on both written assignments and oral participation.

Prerequisite: 85-221

85-355 Introduction to Cognitive Neuroscience

Intermittent: 9 units

Cognitive neuroscience is an emerging interdisciplinary field in which psychological, physiological, and computational methodologies are brought to bear in understanding the neural basis of cognitive processes. In this course, we will consider the application of methodologies such as physiological recordings from neurons in awake, behaving animals, functional neuroimaging (PET and fMRI) of normal subjects performing cognitive tasks, behavioral studies of brain-injured patients with selective cognitive deficits, and computational modeling of normal and impaired processing, in understanding cognitive domains such as high-level vision and attention, learning and memory, reading and language, meaning and semantics, and the organization and control of action. In each instance, the emphasis will be on how the application of converging methodologies, particularly those related to brain organization and function, leads to important insights into the nature of cognitive processes that would be difficult to obtain through any one conventional methodology alone.

Prerequisites: 85-211 or 85-219

85-356 Music and Mind: The Cognitive Neuroscience of Sound

Intermittent: 9 units

This course will take a multidisciplinary approach to understand the neural systems that contribute to auditory perception and cognition, using music and speech as domains of inquiry. Students will master topics in acoustics, psychophysics, cognitive psychology, cognitive development, neurophysiology, and neuropsychology. The early part of the course will provide students with a common foundation in acoustics, signal processing, and auditory neuroscience. Later in the semester, the focus will turn to developing analytical skills through critical evaluation of primary-source experimental literature. Hands-on laboratories and homework sets in sound manipulation and experimentation also will constitute a means of learning about auditory cognitive neuroscience. Throughout, the focus will be upon understanding general cognitive and perceptual challenges in perceiving and producing complex sounds like speech and music. Topics may include biological vs. cultural influences, development in infancy, perception versus production, time perception, effects of experience on perceptual processing, comparative studies of animals, attention, development of expertise, effects of brain damage, and emotional expression. Topics will be addressed from the perspective of cognitive neuroscience, in that we will attempt to understand the neural processes that give rise to auditory perception and cognition.

Prerequisites: (85-219 or 85-370 or 85-211) and (85-320 or 85-340 or 85-310)

85-358 Pro-Social Behavior

Fall: 9 units

This course is an advanced seminar that focuses on social psychological research involving the examination of pro-social behavior. A heavy emphasis will be placed on classic research on helping (which investigates how, when, and why we help strangers), as well as the wide body of literature on social support (which investigates how we help, and seek help from, those who are closer to us). Research on both help-seeking and help-provision will be covered, as well as the implications of this type of pro-social behavior for relationships and health. The course also will cover research on other types of pro-social behavior such as empathy, altruism, forgiveness, and cooperation. This is an advanced seminar in which you will be expected to read original research articles and chapters on assigned topics and come to class prepared to discuss the material. Readings will consist of theoretical and empirical articles from psychology journals and related sources. Additional course requirements will involve short, weekly writing assignments, student presentations of research articles, and a written research proposal. Over the course of the semester, students will design and carry out a small-scale, original investigation on a topic of interest.

Corequisite: 85-340

85-362 Applied Developmental Psychology

Intermittent: 9 units

"Developmentally appropriate" has become a popular label used to describe activities, materials, and environments designed for children. But what does it mean to be developmentally appropriate, and how is it determined? Are these activities and materials evaluated for their impact on children's development or are they simply designed with a superficial interpretation of theoretical positions or empirical findings? How do we decide what theory to apply when designing or evaluating materials, activities, or contexts for children, and are different theories more informative and applicable than others? The purpose of this class is to think deeply about how our theories and research findings have been and could be applied to support and enhance the development of children in a variety of contexts, such as at home, daycare, school, playgrounds, etc. and to evaluate different activities, materials and/or contexts in reference to various theories and empirical findings. The overall purpose of the course is to understand how theory can inform practice and vice versa.

Prerequisite: 85-221

85-363 Attention, Its Development and Disorders

Intermittent: 9 units

This seminar is on attention, its development, and disorders. The seminar will discuss a broad range of topics including: theoretical and practical implications of studying attention (for example, is it really dangerous to talk on the cell phone while driving? does listening to music help studying?); interrelationship of attention with other cognitive processes, such as perception and memory; challenges and opportunities for studying attention in infants and young children; biological and psychological foundations of attention disorders. Classes will consist of a combination of lecture and discussion. Students will be expected to read original research articles, participate in class discussions, make presentations based on readings, and complete a written assignment.

Prerequisites: 85-211 or 85-221

85-370 Perception

Fall: 9 units

Perception, broadly defined, is the construction of a representation of the external world for purposes of thinking and acting. Although we often think of perception as the processing of inputs to the sense organs, the world conveyed by the senses is ambiguous, and cognitive and sensory systems interact to interpret it. In this course, we will examine the sensory-level mechanisms involved in perception by various sensory modalities, including vision, audition, and touch. We will learn how sensory coding interacts with top-down processing based on context and prior knowledge and how perception changes with learning and development. We will look at methods of psychophysics, neuroscience, and cognitive psychology. The goals include not only imparting basic knowledge about perception but also providing new insights into everyday experiences.

85-375 Crosscultural Psychology

Intermittent: 9 units

Human beings share a common genetic inheritance, but our cultural institutions differ in a bewildering variety of ways. This course explores the many different cultural expressions of basic human cognitive and social abilities and needs. We will look at cultural variations in child rearing, mother-child attachment, language socialization, categorization, reasoning, problem-solving, architecture, music, politics, warfare, food-gathering, sex roles, mental disorders, and altered states of consciousness, all with the goal of understanding how the shape of social systems and symbolic expression reflects the economic and adaptive needs of the culture and its people. Among the approaches to these phenomena we will consider are symbolic interaction, cognitive anthropology, dialectic materialism, and modern ethnology.

Prerequisites: 85-100 or 85-102 or 85-198 or 85-211 or 85-219 or 85-221 or 85-251 or 85-241 or 85-261

85-377 Attitudes and Persuasion

Intermittent: 9 units

This advanced undergraduate course will focus on the topic of attitude change and how various persuasive techniques are used to shape human response. The dynamics of propaganda and what makes the techniques effective on social and consumer decisions will be addressed. The primary goals of the course are to 1) understand the dynamics of attitude change; 2) explore the mechanism by which attitude change techniques operate and 3) examine relevant theories and research in persuasion. Examples of topics covered include the origins of attitudes, how attitudes influence judgments, social power and attitude change, and how individual decisions are influenced by the mass media. Classic and contemporary research in the area of persuasion will be examined in the form of course readings and assignments.

Prerequisite: 85-241

85-380 In Search of Mind: The History of Psychology

Intermittent: 9 units

This course will focus on three aspects of the origin and growth of experimental psychology. The first is the prehistory of psychology, where the connection of the discipline to the development of modern science, and in particular, its origins in philosophy and physiology, is examined. The second focus of the course is on the different approaches and attempts to define the field that have contested for dominance during much of the life of the discipline. The final major focus of the course is on the modern period (roughly the last forty years) where the influences that brought about the modern counter-revolution in psychology will be examined, and where some conjecture about likely future directions will occur. Two prior courses in psychology.

85-382 Consciousness and Cognition

Intermittent: 9 units

This course will examine the relationship between cognition and consciousness. One particular focus will be on the issue of how complex the processes that are largely unconsciously controlled may be and another is on the interaction of conscious and non-conscious processes in the control of cognition. We will also very briefly examine relevant ideas about consciousness that arise in other fields such as philosophy of mind and physics. The major topics to be included will be drawn from: the experience and functionality of consciousness, neuroscience approaches to consciousness, perceptual and attentional work on consciousness, cognition in altered states of consciousness (in particular, dreaming), implicit memory, and the proceduralization of higher level cognitive processes. The course will consist of our reading and discussing primary research literature from the above areas. There will be a number of short written assignments based on the weekly reading and a term paper.

Prerequisites: 85-211 or 85-213

85-385 Auditory Perception: Sense of Sound

Intermittent: 9 units

This course explores how our sense of hearing allows us to interact with the world. Students will learn about basic principles of sound, spatial sound, sound quality, hearing impairment, auditory perception, interactions with other modalities, and auditory cognition. Topics may also include musical acoustics, basic auditory physiology, sound-semantic associations, acoustic analysis, and sound-making gestures. We will consider not only simple laboratory-generated signals, but also more complex sounds such as those in our everyday environment, as well as music and speech. Students will gain some in-class experience with generating sounds and analytic listening. After students reach a sophisticated level of understanding of the auditory fundamentals, they will apply their knowledge to the study of several current issues in auditory research.

Prerequisites: 85-102 or 85-211

85-390 Human Memory

Intermittent: 9 units

Without memory, people would barely be able to function: we could not be able to communicate because we would not be able to remember meanings or words, nor what anyone said to us; we could have no friends because everyone would be a stranger (no memory of meeting anyone); we could have no sense of self because we could not remember anything about ourselves either; we could not predict anything about the future because we would have no recollections of the past; we would not know how to get around, because we would have no knowledge of the environment. This course will discuss issues related to memory at all levels: the sensory registers, i.e., how we perceive things; working or short-term memory; long-term memory or our knowledge base. We will discuss the differences between procedural/skill knowledge, and declarative/fact knowledge. The topics of memory monitoring, feeling and knowing, spread of activation within memory (priming), implicit memory, and amnesia will also be covered.

Prerequisites: 85-211 or 85-340 or 85-213

85-392 Human Expertise

Intermittent: 9 units

The process of becoming an expert involves many changes, some quantitative and some qualitative. This course will provide an up-to-date account of the theory and data concerning the development of expertise. Questions addressed include the following. What does it take to become an expert? Are experts born or made? Is the process of acquiring expertise common across different domains from music to sports to science?

Research studied in the course will employ a variety of methodologies, from case studies to protocol analysis to computational modeling.

Prerequisites: 85-211 or 85-213

85-395 Applications of Cognitive Science

Spring: 9 units

The famous psychologist George Miller once said that Psychology should "give itself away." The goal of this course is to look at cases where we have done so — or at least tried. The course focuses on applications that are sufficiently advanced as to have made an impact outside of the research field per se. That impact can take the form of a product, a change in practice, or a legal statute. The application should have a theoretical base, as contrasted, say, with pure measurement research as in ergonomics. Examples of applications are virtual reality (in vision, hearing, and touch), cognitive tutors based on models of cognitive processing, phonologically based reading programs, latent semantic analysis applications to writing assessment, and measures of consumers' implicit attitudes. The course will use a case-study approach that considers a set of applications in detail, while building a general understanding of what it means to move research into the applied setting. The questions to be considered include: What makes a body of theoretically based research applicable? What is the pathway from laboratory to practice? What are the barriers - economic, legal, entrenched belief or practice? The format will emphasize analysis and discussion by students.

85-406 Autism: Psychological and Neuroscience Perspectives

Fall: 9 units

Autism is a disorder that affects many cognitive and social processes, sparing some facets of thought while strongly impacting others. This seminar will examine the scientific research that has illuminated the nature of autism, focusing on its cognitive and biological aspects. For example, language, perception, and theory of mind are affected in autism. The readings will include a few short books and many primary journal articles. The readings will deal primarily with autism in people whose IQ's are in the normal range (high functioning autism). Seminar members will be expected to regularly enter to class discussions and make presentations based on the readings. The seminar will examine various domains of thinking and various biological underpinnings of brain function, to converge on the most recent scientific consensus on the biological and psychological characterization of autism. There will be a special focus on brain imaging studies of autism, including both structural (MRI) imaging of brain morphology and functional (fMRI and PET) imaging of brain activation during the performance of various tasks.

Prerequisites: 85-213 or 85-219 or 85-355 or 85-429 or 85-211

85-408 Visual Cognition

Intermittent: 9 units

Recognizing an object, face or word is a complex process which is mastered with little effort by humans. This course adopts a three-pronged approach, drawing on psychological, neural and computational models to explore a range of topics including early vision, visual attention, face recognition, reading, object recognition, and visual imagery. The course will take a seminar format.

Prerequisites: 85-219 or 85-213 or 85-211

85-412 Cognitive Modeling

Spring: 9 units

This course will be concerned with modeling of agent behavior in a range of applications from laboratory experiments on human cognition, high-performance simulations such as flight simulators, and video game environments like Unreal Tournament. The first half of the course will teach a high-level modeling language for simulating human perception, cognition, and action. The second half of the course will be a project in which students develop a simulated agent or agents for the application of their choice.

Prerequisites: 15-150 or 15-210 or 15-251 or 15-122

85-414 Cognitive Neuropsychology

Spring: 9 units

This course will review what has been learned of the neural bases of cognition through studies of brain-damaged patients as well as newer techniques such as brain stimulation mapping, regional metabolic and blood flow imaging, and attempt to relate these clinical and physiological data to theories of the mind cast in information-processing terms. The course will be organized into units corresponding to the traditionally-defined subfields of cognitive psychology such as perception, memory and language. In each area, we will ask: To what extent do the neurological phenomena make contact with the available cognitive theories? When they do, what are their implications for these theories (i.e., Can we confirm or disconfirm particular cognitive theories using neurological data?)? When they do not, what does this tell us about the parses of the mind imposed by the theories and methodologies of cognitive psychology and neuropsychology?

Prerequisites: 85-219 or 85-211

85-419 Introduction to Parallel Distributed Processing

Spring: 9 units

This course will provide an overview of parallel-distributed processing models of aspects of perception, memory, language, knowledge representation, and learning. The course will consist of lectures describing the theory behind the models as well as their implementation, and students will get hands-on experience running existing simulation models on workstations.

Prerequisites: 85-211 or 85-213

85-421 Language and Thought

Intermittent: 9 units

This course allows the student to explore ways in which the mind shapes language and language shapes the mind. Why are humans the only species with a full linguistic system? Some of the questions to be explored are: What kinds of mental abilities allow the child to learn language? What are the cognitive abilities needed to support the production and comprehension of sentences in real time? How do these abilities differ between people? Are there universal limits on the ways in which languages differ? Where do these limitations come from cognition in general or the specific language facility? Why is it so hard to learn a second language? Are there important links between language change and cultural change that point to links between language and culture?

Prerequisites: 85-213 or 80-150 or 80-180 or 85-211

85-422 Infancy

Intermittent: 9 units

The purpose of this course is to provide students with an extensive background in the field of infant development and to acquaint them with the special methodological and theoretical problems that characterize research in the field. The course will be discussion-oriented and every student will be required to participate actively in both preparing for and contributing to discussion. Specific content areas to be covered include perception, memory, conceptual development, attachment, emotions, social development, and the origins of language. We will cover general readings as well as conflicting empirical studies and theoretical accounts that we will attempt to disentangle and resolve in class discussion.

Prerequisite: 85-221

85-423 Cognitive Development

Intermittent: 9 units

The general goals of this course are that students become familiar with the basic phenomena and the leading theories of cognitive development, and that they learn to critically evaluate research in the area. Piagetian and information processing approaches will be discussed and contrasted. The focus will be upon the development of children's information processing capacity and the effect that differences in capacities have upon the child's ability to interact with the environment in problem solving and learning situations.

Prerequisite: 85-221

85-424 Hemispheric Specialization: Why, How and What?

Intermittent: 9 units

The brain is divided into two hemispheres, raising a host of questions about brain organization, hemispheric specialization and laterality. Despite all the research devoted to these questions, our understanding of the behavioral significance and neural basis of laterality remains limited. This course will address the questions of "why", "how" and "what". We will review the latest data and empirical results but will also develop a coherent theoretical perspective, moving from molecular, genetic and evolutionary considerations to cognitive and clinical factors in the understanding of one of the most fascinating phenomena in neuroscience, neuropsychology, psychiatry, neurology, and cognitive sciences. In addition to tackling a major text in the field (*The Two Halves of the Brain* Edited by Hugdahl and Westerhausen), we will read the latest papers in the field. The class will be almost entirely discussion-based and students will be responsible for doing the readings ahead of time and being prepared for the discussion.

Prerequisites: 85-251 or 85-241 or 85-221

85-425 Child Psychopathology and Treatment

Intermittent: 9 units

The first half of this course will focus on understanding the etiology and epidemiology of child and adolescent psychopathology. Special emphasis will be placed on conditions that are first diagnosed during childhood (e.g., ADHD, Autism, Eating Disorders) as well as understanding how child and adult psychopathology differ. The second half of this course will focus on treatment interventions for youth with psychopathology. Students will learn about how interventions for adults with psychopathology are altered to be developmentally appropriate for children, and methods of intervention commonly used with children but less so with adults (e.g., family therapy, play therapy). For students who have completed abnormal psychology and the psychology breadth requirement but not the other course pre-requisite, 85102, please see Theresa Kurutz to register for this course in BH 343.

Prerequisites: 85-261 and 85-102

85-426 Learning in Humans and Machines

Spring: 9 units

This course provides an introduction to probabilistic models of cognition. The focus is on principles that can help to explain human learning and to develop intelligent machines. Topics discussed will include categorization, causal learning, language acquisition, and inductive reasoning.

Prerequisite: 15-112

85-428 Neuro Basis of Cognitive Development

Intermittent: 9 units

In this seminar, we will examine the neural basis of cognitive development by linking the functional properties of the developing child, as they are described in Piagetian and neo-Piagetian theories, to the neural systems that support them drawing on the framework provided by computational modeling. The focal issues will be the mapping between functional models and neural models, the normal unfolding of development, the interaction of learning and development, and brain plasticity. The systems to be discussed are (1) language, (2) visuo-spatial processing, (3) learning and attention, (4) complex problem solving, and (5) perceptual-motor functions. The goal of the seminar is to relate and integrate insights from three disciplines: cognitive developmental psychology, neuroscience and computational modeling. The format of the course will be discussions of the readings along with various exercises to explore each component discipline and their interrelation in more detail. For example, some of the exercises involve an introduction to brain imaging, an introduction to computational modeling, and further explorations of psychological experimentation, all within the context of cognitive development.

Prerequisites: 85-414 or 85-412 or 85-411 or 85-219 or 85-213 or 85-211 or 85-419 or 85-423 or 85-429

85-429 Cognitive Brain Imaging

Spring: 9 units

This seminar will examine how the brain executes higher level cognitive processes, such as problem-solving, language comprehension, and visual thinking. The topic will be addressed by examining what recent brain imaging studies can tell us about these various kinds of thinking. This new scientific approach has the potential of providing important information about how the brain thinks, indicating not only what parts perform what function, but also how the activity of different parts of the brain are organized to perform some thinking task, and how various neurological diseases (e.g. aphasia, Alzheimer's) affect brain activity. A variety of different types of thinking will be examined, including short-term working memory storage and computation, problem solving, language comprehension, visual thinking. Several different technologies for measuring brain activity (e.g. PET and functional MRI and also some PET imaging) will be considered, attempting to relate brain physiology to cognitive functioning. The course will examine brain imaging in normal subjects and in people with various kinds of brain damage.

Prerequisites: 85-213 or 85-412 or 85-414 or 85-419 or 85-211

85-442 Health Psychology

Intermittent: 9 units

This course is concerned with how behavior and psychological states influence the development of and recovery from disease. The class provides an overview of existing psychological and epidemiological data on the relationship between behavior and disease and addresses the issue of how behavior, emotion and cognition can influence the disease processes. Topics include: measures and concepts, stress and disease, stress and coping, personal control, helplessness and disease, social support and health, reactivity to stress, behavior and hypertension, coronary heart disease, infectious diseases and immune function, and the effectiveness of behavioral interventions in health. Only Juniors and Seniors will be admitted into the course and instructor permission is required.

85-443 Social Factors and Well-Being

Intermittent: 9 units

This course will focus on the role that our social environment plays in our feelings of well-being and in the maintenance of our mental and physical health. Topics to be discussed include marriage, widowhood, loneliness, social support, social participation, social aspects of personality (e.g., social anxiety, extraversion, agreeableness, and hostility), social stressors (betrayal and conflict), discrimination, and socioeconomic status. We will consider how each social factor develops, the extent to which we can alter it or its effects on our lives, and how it influences our overall well-being. Only Juniors and Seniors will be admitted into the course and instructor permission is required.

85-444 Relationships

Fall: 9 units

The primary goal of this course is to introduce you to social psychological theory and research on the topic of relationships. Although a variety of relationship phenomena will be discussed, a heavy emphasis will be placed on research that addresses fundamental processes in close relationships. The coverage of material will include a review of historical roots and classic approaches to the scientific study of relationships, as well as exciting new research and theory on particular subtopics. The majority of class time is spent discussing and evaluating recent research. Special emphasis also is given to learning and critically evaluating the methodological tools that are used to study close relationships. The goal is for students to leave this course with a broad overview of the field and an in-depth understanding of particular subtopics. This is an advanced seminar in which students will be expected to read original research articles and chapters on assigned topics and come to class prepared to discuss the material. Readings will consist of theoretical and empirical articles from psychology journals and related sources. Additional course requirements will involve short, weekly writing assignments, student presentations of research articles, and a written research proposal. Over the course of the semester, students will design and carry out a small-scale, original investigation on a relationships topic of interest.

Prerequisite: 85-340

85-446 Psychology of Gender

Spring: 9 units

This course is devoted to the investigation of psychological gender rather than biological sex. That is, sex differences will be explored from a social psychological (e.g., socialization) perspective. Implications of both male gender role and female gender role in the areas of relationships and health will be the course focus.

Prerequisites: 85-251 or 85-241

85-480 Internship in Clinical Psychology

All Semesters

This course introduces students to Clinical Psychology and related mental health fields. Students' learning is facilitated through classroom-based activities and by learning about clinical research and/or practice in designated field settings. Students spend 3 hours per week in contact and 6 hours per week in an applied or research setting. Please contact Dr. Beth Zimick if you are interested in enrolling at bethc@andrew.cmu.edu.

Prerequisites: 85-251 or 85-261

85-481 Seminar in Intervention

Intermittent: 9 units

This course is an introduction to the therapeutic process. Students will be introduced to a variety of therapeutic approaches and techniques (e.g. Solution-Focused, Cognitive, Client Centered, etc.) and will have the opportunity to learn the basic skills associated with each (e.g. Cognitive Restructuring, Mirroring, Empathic Highlighting, etc.). Instruction will entail a mix of discussion and demonstration, and there will be a heavy emphasis on in-class practice of these skills.

Prerequisites: (85-251 and 85-261) or (85-281 and 85-261) or (85-281 and 85-251)

85-482 Internship in Psychology

Fall and Spring

The Internship in Psychology is designed to enable students to gain experience in professional settings related to their studies in Psychology and earn credit for the intellectual work involved. It is the students responsibility to locate an internship site and on-site supervisor, as well as to identify a CMU faculty sponsor. The student registers for the internship by submitting a completed internship form to Theresa Kurtz in Baker Hall 343.

85-484 Practicum in Child Development

Fall and Spring: 9 units

This guided field experience is designed to help students deepen their understanding of developmental psychology by assisting in a preschool or kindergarten classroom and discussing the ways that their experiences relate to the theories they have learned previously and to new readings. Each student will individually schedule a consistent 6 hours per week helping in a Children's School classroom (preferably 2 or 3 chunks of time). Classroom duties will include working one-on-one and with small groups of students as they do puzzles, art projects, dramatic play, etc., as well as helping with snack, playground supervision, classroom cleanup, and storytime. Each student will be expected to keep a journal 1) relating general experiences to developmental theories and 2) documenting the development of a particular child during the semester. All students will meet for a 1 hour weekly discussion with the director. Discussion topics and related readings will be selected collaboratively, based on issues/questions raised by the group's observations and discussions.

Prerequisite: 85-221

85-501 Stress, Coping and Well-Being

Intermittent: 9 units

This course will examine basic processes and theory about stress and coping from a psychological perspective. The first part of the course will explore topics related to the psychobiology of stress, stress measurement, and links between stress and health. The second part of the course will explore topics on mechanisms and theoretical perspectives on coping with stress. This will include a consideration of topics such as emotion regulation, self-regulation, coping with traumatic events, alternative medicine approaches, and resilience factors. This class is a small, upper level seminar that will consist of some lecture and extensive class discussion. Active class participation is required.

Prerequisites: 85-310 or 85-320 or 85-340

85-505 Readings In Psychology

All Semesters

As the name implies, the emphasis in the Reading course is on reading articles and books in some specified area. The students work in the course must lead to the production of a written paper which will be read by the instructor directing the readings. Often the reading is related to a research project which the student may wish to conduct. Readings courses have also been used to give students an opportunity to receive instruction in areas which are not included elsewhere in our course listing. The course may be taken for any number of units up to 9, depending upon the amount of work to be done.

85-506 Readings in Psychology

Fall and Spring

As the name implies, the emphasis in the reading course is on reading articles and books in some specified area. The students work in the course must lead to the production of a written paper which will be read by a psychology faculty instructor directing the readings. Often the reading is related to a research project which the student may wish to conduct. Reading courses have also been used to give students an opportunity to receive instruction in areas which are not included elsewhere in our course listing. The course may be taken for any number of units up to 9, depending upon the amount of work to be done. This course is special permission and can only be added in consultation with a psychology faculty member and registered by the Undergraduate administrator, Emilie O'Leary emilier@andrew.cmu.edu.

85-507 Research in Psychology

Fall

This course may include field study, applied work, or laboratory research. The student should have previous training in the basic research skills that will be used in his/her project, especially statistical methods and experimental design. Independent Research Projects will be supervised by a faculty member and must result in a written paper. It is the students responsibility to make arrangements for independent study courses with individual faculty members. This should be done the semester before a student wishes to register for one of these courses. The course may be taken for any number of units up to 12, depending upon the amount of work to be done. Please contact the CMU psychology faculty member you wish to work with to get approval to enroll then email Emilie Rendulic at emilier@andrew.cmu.edu in order to be registered for the course.

85-508 Research in Psychology

Spring

This course may include field study, applied work, or laboratory research. The student should have previous training in the basic research skills that will be used in his/her project, especially statistical methods and experimental design. Independent Research Projects will be supervised by a faculty member and must result in a written paper. It is the students responsibility to make arrangements for independent study courses with individual faculty members. This should be done the semester before a student wishes to register for one of these courses. The course may be taken for any number of units up to 12, depending upon the amount of work to be done.

85-601 Senior Thesis

Fall: 9 units

This course is intended for senior Psychology or Cognitive Science majors who wish to conduct a research project under the direction of a faculty advisor. The project topic is to be selected jointly by the student and the advisor. The project will culminate in a senior paper which will be presented to the Department Head at the end of Fall Semester. Prerequisite: Grade of B or better in a previous research course required to enter, grade of B or better in first semester of senior thesis course required to complete, and permission of instructor. A formal proposal is required in the first semester. This course differs from the Honors Thesis sequence (66-501,502) in that it does not require Honors standing in HSS (i.e., there are no QPA requirements). This course differs from Research in Psychology (85-507,508) in that the student's original contribution to the research is expected to be more substantial, and in that a final written report of the project is to be presented to the Department.

85-602 Senior Thesis

Spring: 9 units

This course is intended for senior Psychology or Cognitive Science majors who wish to conduct a research project under the direction of a faculty advisor. The project topic is to be selected jointly by the student and the advisor. The project will culminate in a senior paper which will be presented to the Department Head at the end of Fall Semester. Prerequisite: Grade of B or better in a previous research course required to enter, grade of B or better in first semester of senior thesis course required to complete, and permission of instructor. A formal proposal is required in the first semester. This course differs from the Honors Thesis sequence (66-501,602) in that it does not require Honors standing in HSS (i.e., there are no QPA requirements). This course differs from Research in Psychology (85-507,508) in that the student's original contribution to the research is expected to be more substantial, and in that a final written report of the project is to be presented to the Department.

85-730 Analytic Research Methods

Intermittent: 12 units

This class will teach students how to apply six major non-experimental research methods used in analytic behavioral analysis. Protocol Analysis. This method is used to study patterns and changes in problem-solving and their matches to theoretical models, including computational models. Corpus Analysis. This method is used to isolate patterns of behavioral and communication usage and change, as revealed through the study of the world-wide web and large computerized databases such as CHILDES, TalkBank, or the British National Corpus. Tools here include text searches and data-mining. Conversation Analysis. This is a microanalytic method used to examine sequencing, repair, and orientation in closely transcribed recordings of spoken interactions, as made available through systems such as the CABank database, as well as recorded programs on YouTube and elsewhere. Coding Systems. This approach seeks to capture interactional and behavioral structures in writing, teaching, interview, and other interactions. Here, there will be a special emphasis on the coding of instructional interactions. Gesture Analysis. This microanalytic method seeks to track patterns in gestural and nonverbal communication, often in association with spoken messages. Profile Analysis. This approach studies differences across learners at various ages and ability levels and group differences involving aphasia, autism, stuttering, dementia, and other individual differences. Students will work with data already available from previous studies, and will also learn to collect their own new datasets. Although the data being examined have been generated through naturalistic processes, they can be analyzed quantitatively using time-series analyses, non-parametric statistics, error matrices, and neural network simulations. In these various analyses, we will also consider how behavioral patterns are shape

85-765 Cognitive Neuroscience

Intermittent

This course will cover fundamental findings and approaches in cognitive neuroscience, with the goal of providing an overview of the field at an advanced level. Topics will include high-level vision, spatial cognition, working memory, long-term memory, learning, language, executive control, and emotion. Each topic will be approached from a variety of methodological directions, for example, computational modeling, cognitive assessment in brain-damaged humans, non-invasive brain monitoring in humans, and single-neuron recording in animals. Lectures will alternate with sessions in seminar format. Prerequisites: Graduate standing or two upper-level psychology courses from the areas of developmental psychology, cognitive psychology, computational modeling of intelligence, neuropsychology or neuroscience.

Public Policy Mgt:Sch of Pub Pol Mgt Courses**90-708 Healthcare Ethics**

Spring and Summer: 6 units

This course will survey several important ethical issues problems and dilemmas that arise in the context of the delivery of healthcare. It will begin with discussions that focus upon the nature of ethics in general and applied ethics in particular. The goal of this introductory portion of the course will be to establish a healthcare decision making framework that will be used during the remaining sections of the course. Topics introduced here will include: theoretical and applied ethics moral pluralism principlism the differences between absolutism relativism and pluralism and prudential reasoning as a tool of ethical analysis in healthcare. The specific healthcare areas that will be discussed and analyzed from a normative perspective include: determining the beginning and the end of human life the ethical questions surrounding abortion end of life issues such as euthanasia and physician assisted suicide various reproductive issues medical research ethics ethics in the medical treatment of infants and children transplantation issues and the ethics of medical genetics. The course will proceed by means of lectures small and large group discussions and the analysis of well-known essays and case studies in healthcare ethics.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=6>

90-718 Strategic Presentation Skills

Fall and Spring: 6 units

This seven-week course focuses on important elements for creating and delivering presentations in professional settings. Assignments include a persuasive briefing, an informative or introductory speech, interview practice, and impromptu speaking exercises. A variety of learning methods are utilized to research topics, organize ideas, write speeches, develop visuals, and interact with audience members. This course will help students develop confidence as skilled presenters.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=477>

90-721 Healthcare Management

Fall: 6 units

This course introduces the values knowledge and skills required to strategically manage the rapidly changing internal and external environment of health care organizations. The course is designed to provide students with a solid foundation in contemporary health care management practices.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=19>

90-758 Ethics & Public Policy in a Global Society

Spring: 6 units

The first section of the mini-course will be devoted to a discussion of the nature of ethics and applied ethics. Here a framework useful in the ethical analysis of issues problems and dilemmas in public life will be constructed. The second section of the course will demonstrate the usefulness of this framework in the analysis and evaluation of policy issues from a normative point of view. In this section various arguments concerning the nature of the social ethics that form the background of policy debates also will be a focus in the mini-course. The course will consider: reproductive rights matters end-of-life decisions questions about free speech social and economic justice and environmental considerations.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=58>

90-765 Cities, Technology and the Environment

Fall: 6 units

This course will explore the interaction of cities, technology and the natural environment over time. More specifically, it will consider the evolution of several major issues confronting cities today: (1) water supply, wastewater disposal and flooding; (2) Energy and Environment; (3) Transportation, suburbanization and land use; and (4) Brownfield creation and development. In a number of instances, the Pittsburgh region will be used to provide examples of these issues. These themes will be approached through a combination of class discussions, lectures, and visiting speakers. Class participation is expected, and will comprise a portion of the grade. Upon completion of this course, the student will be able to: 1. Analyze the interaction of cities, technology and the natural environment over time. 2. Be cognizant of the major issues confronting cities today, (1) water supply, wastewater disposal and flooding; (2) Energy and Environment; (3) Transportation, suburbanization and land use; and (4) Brownfield creation and development. 3. Write a thought-paper that explores a relevant problem, discusses its evolution and turning points, and suggests policy options.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=73>

90-789 Sustainable Community Development

Spring: 12 units

This course will involve in-depth examination of the economic and social value that is created when development occurs in a sustainable manner. The various components of comprehensive community development will be defined through class lectures guest speakers and case studies. These components will include: housing business and economic development cultural and social development transportation systems and open spaces. Economic and design comparisons will be drawn between sustainable and non-sustainable models of development. The course will also consider how public policy and private decision-making can be influenced by well-organized community planning and advocacy efforts.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=69>

90-798 Environmental Policy & Planning

Fall: 12 units

Environmental Policy and Planning provides an introduction to how environmental policies have been and can be designed/created implemented and evaluated amidst complex information-based social political and cultural processes. The course emphasizes a systems-based methodological approach for addressing the complexities involved in framing analyzing and designing an implementation plan for policy construction. The course also explores through landmark and contemporary case studies several dimensions of environmental policymaking: * Contextual historical and structural aspects of environmental policymaking at the local state federal and international levels * Use of quantitative and qualitative analytical tools (from the core program as well as new tools) * The process of how policies derive their meaning. Students in this course work on a final environmental policy project to demonstrate mastery of the knowledge and skill-based exercises explored during the term.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=85>

90-808 Energy Policy

Fall: 6 units

This seminar will provide an introduction to modern U.S. energy policy. What lessons have we learned from past initiatives? How different is our current policy? How much influence does government really have? How does the U.S. interact with other countries? The class will begin with a discussion of the U.S. policy reaction to Arab oil embargoes of the 1970s — which resulted in the creation of the U.S. Energy Department and the first significant attempts to move the country from a dependence on (imported) oil. Besides describing the U.S. government components that play a role in the development and implementation of energy policy we will also analyze many of the relevant policy levers: economics technology politics public opinion and national security. The class will then turn to more recent developments - studying the development and implementation of energy legislation during the last decade. We will also focus on a few case studies — such as the Keystone Pipeline the Cape Wind Project and the development of the Marcellus Shale — that demonstrate conflicting viewpoints about appropriate energy policy. Finally we will conduct a crisis simulation in order to explore the national security implications of a global oil disruption. Each class will begin with a short discussion of current events in the energy sector. There will also be a number of guest lecturers including senior government officials.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=98>

90-818 Health Care Quality & Performance Improvement

Spring and Summer: 6 units

This course provides an overview of the current state of the quality movement in Health Care. A public health perspective as well as an individual perspective will be considered from both a U. S. and international view. Relevant history current gurus landmark publications theories tools and environmental factors will be discussed and utilized. We will explore the cost/quality connection and analyze the complex forces that shape or hinder the transformation of health care from the current state to a person centered quality focused Health Care System.

Prerequisite: 90-836

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=440>

90-830 Introduction to Financial Management of Health Care

Fall: 6 units

This course is designed to provide students with a general understanding of health systems financial management. Students will acquire technical expertise and analytical skills to evaluate financial matters encountered in the overall management of health systems (e.g. hospitals physician practices integrated delivery systems and nursing homes). Non-financial health care managers should develop practical skills to assess financial implications of future federal/state health policy and budget decisions. Many students find this course to be helpful as background for other health care elective courses. This course will include: Lectures and extensive textbook readings to familiarize students with health systems financial management functions. Historical perspectives will include a macroeconomic overview of health expenditures and the evolution of third-party payors. Detailed review of current payment and reimbursement systems for providers and insurers including Medicare and Medical Assistance. Lectures by guest speakers who will share their experiences in applying financial management theories within various health care situations. Presentation of case studies which provide students an opportunity to apply their skills to practical situations.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=116>

90-831 Advanced Financial Management of Health Care

Fall: 6 units

The mini-course is designed to provide the students with a practical understanding of the challenges in managing a healthcare facility. Through the use of actual data guest speakers from Children's management and a major healthcare insurance company students will develop an understanding of the challenges that were faced by the hospital over the past decade. As the sole pediatric facility in the area Children's experienced positive financial results and little competition until the early 1990's. This was the result of increased penetration of managed care into the region and insurance companies purchasing physician practices. Children's responded like many facilities by attempting to cut costs and buy practices in order to protect market share. What occurred is that such actions caused further deterioration in the financial results. Fiscal Year 1997 produced the worst financial results in the hospital's history causing the Board to take drastic actions. What followed was during a five year period operating results improved by approximately \$25 million as a result of changing leadership going back to business-basics and creating a greater sense of accountability throughout the organization. Although Children's will be used as a case study the topics discussed are applicable to any healthcare institution. Advance work will include financial statement review and analysis. The on-campus classroom sessions will include guest speakers and discussion of real life challenges experienced at Children's Hospital over the last 10 years. The principal topic areas of the course are: Financial Statement Analysis Revenue Cycle components Contracting challenges Expense management Physician practice models Nursing challenges Leadership Non-profits accessing Capital

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=117>

90-832 Health Law

Fall: 6 units

This course explores the law related to provision of health care and governing health care institutions. Starting with an examination of the structure of the United States legal system this course then examines some of the statutes regulations and cases whose subjects are the provision of health care services in the US. Topics covered include malpractice patient rights reimbursement research and death and dying. The course requires extensive reading which is provided on Blackboard and which is primarily composed of original sources such as Supreme Court cases and federal and state statutes and regulations. There is an optional take-home midterm and a required take-home final.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=118>

90-836 Health Systems

Fall: 6 units

This is a 6-unit course designed to provide students with an introduction to the structure operation and functioning of health care systems. It is a core course for students in the Master of Science of Health Care Policy and Management (HCPM) program and is a prerequisite for most of the courses in the program that follow. This course provides a broad overview of the multiple systems that define describe and shape health care systems with a particular emphasis on the U.S. health care system. The learning objectives of this course are to: - Gain factual knowledge of the broad elements and overall principles of U.S. Health Care System - Develop an understanding of the dynamics of health care systems involving interaction of patients health care providers sources of health care financing insurance and regulatory and quasi-regulatory organizations. - Understand the key external forces that influence health services including social economic political demographic and epidemiological factors. - Describe significant components of the U.S. health care system discuss the interaction among elements of the health system review the ongoing development of health services and systems and relate health services to major social and other external forces. - Define and apply health systems terminology - Acquire and enhance skills in gathering and presenting information about health care systems and demonstrate familiarity with major sources of information of health care systems and service delivery.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=366>

90-861 Health Policy

Fall: 6 units

This course introduces students to the concepts, theories, and tools of health policy. The aims of this course are to provide students with (1) the ability to identify key problems facing the United States health system, (2) increase the appreciation for and understanding of health policy as an important and useful tool for enhancing population health, and (3) mechanisms to address a current health policy issue from legal, economic, behavioral, and political perspectives. In addition, students will be introduced to a cross-national comparison of health systems. Prerequisite: 90-836

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=140>

90-863 Health Policy II

Spring: 6 units

This course teaches how to conduct policy analysis in the area of health care. Students will learn how to identify a problem clearly evaluate alternative proposals and their potential impacts and communicate effectively with policymakers. We will build on the institutional background and conceptual frameworks from the Health Systems and Health Policy I courses. Here students will focus on a particular policy issue and will produce a detailed written analysis and in-class presentation on their topic. To provide examples lectures will cover a range of policy challenges including cost containment retirement-age policy health disparities pharmaceutical safety and innovation and medical malpractice.

Course Website: <http://www.heinz.cmu.edu/academic-resources/course-results/course-details/index.aspx?cid=142>

Robotics Courses**16-223 Introduction to Physical Computing**

Fall: 10 units

Physical computing refers to the design and construction of physical systems that use a mix of software and hardware to sense and respond to the surrounding world. Such systems blend digital and physical processes into toys and gadgets, kinetic sculpture, functional sensing and assessment tools, mobile instruments, interactive wearables, and more. This is a project-based course that deals with all aspects of conceiving, designing and developing projects with physical computing: the application, the artifact, the computer-aided design environment, and the physical prototyping facilities. The course is organized around a series of practical hands-on exercises which introduce the fundamentals of circuits, embedded programming, sensor signal processing, simple mechanisms, actuation, and time-based behavior. The key objective is gaining an intuitive understanding of how information and energy move between the physical, electronic, and computational domains to create a desired behavior. The exercises provide building blocks for collaborative projects which utilize the essential skills and challenge students to not only consider how to make things, but also for whom we design, and why the making is worthwhile. This course is an IDEATe Portal Course for entry into either of the IDEATe Intelligent Environments or Physical Computing programs. CFA/DC/TPR students can enroll under 16-223; CIT/MCS/SCS students can enroll in the 60-223 version of the course. Please note that there will be lab usage and materials fees associated with this course.

16-233 TBAIntermittent: 10 units
TBA**16-264 Humanoids**

Spring: 12 units

This course surveys perception, cognition, and movement in humans, humanoid robots, and humanoid graphical characters. Application areas include more human-like robots, video game characters, and interactive movie characters.

Course Website: <http://www.cs.cmu.edu/~cga/humanoids-ugrad/>

16-299 Introduction to Feedback Control Systems

Spring: 12 units

This course is designed as a first course in feedback control systems for computer science majors. Course topics include classical linear control theory (differential equations, Laplace transforms, feedback control), linear state-space methods (controllability/observability, pole placement, LQR), nonlinear systems theory, and an introduction to control using computer learning techniques. Priorities will be given to computer science majors with robotics minor.

Prerequisites: 21-122 and 15-122

16-311 Introduction to Robotics

Spring: 12 units

This course presents an overview of robotics in practice and research with topics including vision, motion planning, mobile mechanisms, kinematics, inverse kinematics, and sensors. In course projects, students construct robots which are driven by a microcontroller, with each project reinforcing the basic principles developed in lectures. Students nominally work in teams of three: an electrical engineer, a mechanical engineer, and a computer scientist. This course will also expose students to some of the contemporary happenings in robotics, which includes current robot lab research, applications, robot contests and robots in the news.

Prerequisites: 24-311 or 21-260 or 21-241 or 21-240 or 18-202

Course Website: <http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/>

16-362 Mobile Robot Programming Laboratory

Fall: 12 units

This course is a comprehensive hands-on introduction to the concepts and basic algorithms needed to make a mobile robot function reliably and effectively. We will work in small groups with small robots that are controlled over wireless from your laptop computers. The robots are Neato household vacuum robots that have been converted to mini forklifts that can move pallets from place to place just like commercial automated guided vehicles do today. The robots are programmed in the modern MATLAB programming environment. It is a pretty easy language to learn, and a very powerful one for prototyping robotics algorithms. You will get a lot of experience in this course in addition to some theory. Lectures are focused on the content of the next lab. There is a lab every week and they build on each other so that a complete robot software system results. The course will culminate with a class-wide robot competition that tests the performance of all of your code implemented in the semester. In order to succeed in the course, students must have a 2nd year science/engineering level background in mathematics (matrices, vectors, coordinate systems) and have already mastered at least one procedural programming language like C or Java. When the course is over, you will have written a single software system that has been incrementally extended in functionality and regularly debugged throughout the semester.

Course Website: <http://www.frc.ri.cmu.edu/~alonzo/teaching/16x62/16x62.html> <http://www.youtube.com/watch?v=skk0eGW5>

16-371 Personalized Responsive Environments

Spring: 9 units

[IDeATe collaborative course]. Environmental factors have a significant impact on mood and productivity. Creating responsive environments necessitates the design of surroundings that are able to metamorphose in order to optimize user strengths and available resources and evolve in stride with user needs. This course will investigate the development of spaces that adapt to user preferences, moods, and task specific demands. Both the design and engineering of such personalized environments will be explored. Central course concepts will include, understanding the user, integrating various modalities (e.g., light, heat, sound) to support the changing needs of task and user, and the creation of adaptive environments that learn user preferences over time. Please note that there may be usage/materials fees associated with this course.

Prerequisites: 15-104 or 18-090 or 62-150 or 60-223

16-375 Robotics for Creative Practice

Fall: 10 units

[IDeATe collaborative course]. This project-oriented course brings art and engineering together into making machines which are surprisingly animate. Students will iterate their concepts through several small projects focused on using embodied behavior as a creative medium for storytelling, performance, and human interaction. Students will learn skills for designing, constructing and programming simple robot systems, then exploring their results through exhibition and performance. Technical topics include systems thinking, dynamic physical and computational behavior, autonomy, embedded programming, and fabrication and deployment. Discussion topics include both contemporary kinetic sculpture and robotics research. Please note that there may be usage/materials fees associated with this course.

Prerequisites: 60-223 or 15-104 or 16-223 or 62-150

16-384 Robot Kinematics and Dynamics

Fall: 12 units

Foundations and principles of robotic kinematics. Topics include transformations, forward kinematics, inverse kinematics, differential kinematics (Jacobians), manipulability, and basic equations of motion. Course also include programming on robot arms.

Prerequisites: 15-122 or 24-311 or 21-241 or 18-202 or 16-311

16-385 Computer Vision

Spring: 9 units

Basic concepts in machine vision, including sensing and perception, 2D image analysis, pattern classification, physics-based vision, stereo and motion, and object recognition.

Prerequisites: (15-122 and 18-202) or (21-259 and 15-122 and 21-241)

16-397 Art, Conflict and Technology in Northern Ireland

Spring: 12 units

Art, Conflict and Technology in Northern Ireland is a 12-unit course cross-listed between the School of Art, the Department of English, and the Robotics Institute. Throughout the term students will be introduced to a history of social strife in the North of Ireland from the 1960s to the present, and efforts to reconcile such differences in the contemporary period. We will consider the influence of advancing technology on how narratives are shared within a community and worldwide. We will reflect upon and analyze a variety of literary and visual art sources from the chosen time period, while also learning how to create mixed-media projects using Gigapan and Hear Me systems from Carnegie Mellon's CREATE Lab in the Robotics Institute. If you have ever considered how artists explore societal strife through their writing or visual arts practice, if you are interested in the social and political influences of evolving technology, or if you are a practicing artist who uses advancing technology as a tool for individual expression, this integrative course is for you. Throughout the semester we will examine the practice of a range of visual artists that include Rita Duffy, John Kindness and Willie Doherty and writers and dramatists like Dermot Healy, Patrick McCabe, and Christina Reid. Students will learn how to use CREATE Lab's Gigapan and Hear Me systems as platforms for exploring the content presented in the class for the development of final projects. We will travel to Belfast for spring break 2015, to meet a variety of writers and artists whose work we will study, and stakeholders in the reconciliation efforts throughout the region. In addition to weekly lectures on Thursdays throughout the term, students will have a six-week lab on Tuesdays. Lab sessions begin in the second week of classes (January 20).

16-421 Vision Sensors

Spring: 12 units

This course covers the fundamentals of vision cameras and other sensors - how they function, how they are built, and how to use them effectively. The course presents a journey through the fascinating five hundred year history of "camera-making" from the early 1500's "camera obscura" through the advent of film and lenses, to today's mirror-based and solid state devices (CCD, CMOS). The course includes a significant hands-on component where students learn how to use the sensors and understand, model and deal with the uncertainty (noise) in their measurements. While the first half of the course deals with conventional "single viewpoint" or "perspective" cameras, the second half of the course covers much more recent "multi-viewpoint" or "multi-perspective" cameras that includes a host of lenses and mirrors.

Prerequisites: 21-111 and 21-241

Course Website: <http://www.cs.cmu.edu/~ILIM/courses/vision-sensors/>

16-423 Designing Computer Vision Apps

Fall: 12 units

Computer vision is a discipline that attempts to extract information from images and videos. Nearly every smart device on the planet has a camera, and people are increasingly interested in how to develop apps that use computer vision to perform an ever expanding list of things including: 3D mapping, photo/image search, people/object tracking, augmented reality etc. This course is intended for students who are not familiar with computer vision, but want to come up to speed rapidly with the latest in environments, software tools and best practices for developing computer vision apps. No prior knowledge of computer vision or machine learning is required although a strong programming background is a must (at a minimum good knowledge of C/C++). Topics will include using conventional computer vision software tools (OpenCV, MATLAB toolboxes, VLFeat, CAFFE), and development on iOS devices using mobile vision libraries such as GPUImage and fast math libraries like Armadillo and Eigen. For consistency, all app development will be in iOS and it is expected that all students participating in the class have access to an Intel-based MAC running OS X Mavericks or later. Although the coursework will be focussed on a single operating system, the knowledge gained from this class is intended to generalize to other mobile platforms such as Android etc.

Prerequisites: (15-213 and 21-240) or (15-213 and 21-241) or (18-213 and 18-202)

Course Website: http://www.cs.cmu.edu/~slucey/Design_CV

16-450 Robotics Systems Engineering

Fall: 12 units

Systems engineering examines methods of specifying, designing, analyzing and testing complex systems. In this course, principles and processes of systems engineering are introduced and applied to the development of robotic devices. The focus is on robotic system engineered to perform complex behavior. Such systems embed computing elements, integrate sensors and actuators, operate in a reliable and robust fashion, and demand rigorous engineering from conception through production. The course is organized as a progression through the systems engineering process of conceptualization, specification, design, and prototyping with consideration of verification and validation. Students completing this course will engineer a robotic system through its compete design and initial prototype. The project concept and teams can continue into the Spring-semester (16-474 Robotics Capstone) for system refinement, testing and demonstration. Prerequisites: 16-311 and (16-299 or 24-451 or 18-370)

16-455 Human-Machine Virtuosity

Spring: 12 units

Human dexterous skill embodies a wealth of physical understanding which complements computer-based design and machine fabrication. This project-oriented course explores the duality between hand and machine through the practical development of innovative design and fabrication systems. These systems fluidly combine the expressivity and intuition of physical tools with the scalability and precision of the digital realm. Students will develop novel hybrid design and production workflows combining analog and digital processes to support the design and fabrication of their chosen projects. Specific skills covered include 3D scanning, 3D modeling (CAD), 3D printing (additive manufacturing), computer based sensing, and human-robot interaction design. Areas of interest include architecture, art, and product design. Prerequisites: 16-223 or 60-223

16-456 Advanced Topics in Reality Computing: The Adaptive Home

Fall: 12 units

[IDeATe collaborative course]. The Adaptive House is the focus of an advanced design studio based around the collaborative development of reality computing applications within a residential prototype. Reality computing encompasses a constellation of technologies focused around capturing reality (laser scanning, photogrammetry), working with spatial data (CAD, physical modeling, simulation), and using data to interact with and influence the physical world (augmented / virtual reality, projector systems, 3d printing, robotics). This studio will use reality computing to understand existing homes, define modes of augmentation, and influence the design of houses yet to be built through full scale prototyping. The objective of the course will be the production of a house that moves beyond the notion of being "smart", but is actively adapted towards its inhabitants? needs and capabilities. Topics of special focus within the course are residential design (John Folan), augmented reality and robotics (Pyy Matikainen), and indoor flying robots (Manuela Veloso and Nina Barbuto). Please note that there may be usage/materials fees associated with this course. This course is presented with the support and cooperation of Autodesk, Inc. Fall 2015 course website: <http://www.rc16456.com/>.

16-461 Experimental Capture

Fall: 9 units

Performance capture is used in applications as varied as special effects in movies, animation, sports training, physical rehabilitation, and human-robot/human-computer interaction. This course will survey state-of-the-art techniques and emerging ideas, in the industry and in academia, to capture, model, and render human performances. The course will be a mix between lectures and discussion of recent progress in human motion capture and analysis. The course evaluation will be project-based, in which students will capture their own body and face motion, and build projects around the data they collect individually and as a group. We will cover: 1. Capture Techniques: We will describe and use various systems including motion capture, video-based capture, depth sensors, scanners, and eye-gaze trackers; 2. Modeling and Representation: We will cover classic and contemporary representations of face and body pose and motion, including statistical and physics-based techniques; 3. Rendering Applications: As new rendering paradigms emerge, new applications continue to develop. We will study recent progress in animation, synthesis, classification, and rehabilitation on new forms of displays. Please note that there may be usage/materials fees associated with this course. Prerequisites: 15-365 or 60-422

16-465 Game Engine Programming

Spring: 10 units

This course is designed to help students understand, modify, and develop game engines. Game engines consist of reusable runtime and asset pipeline code. They provide game-relevant abstractions of low-level system services and libraries, making it easier to write bug-free games that work across multiple platforms. Game engines also handle artistic content, providing or integrating with authoring tools to ease the process of creating high-fidelity games. In this course, we will discuss the problems game engines attempt to solve, examine how current state-of-the-art engines address these problems, and create our own engines based on what we learn. We will cover both the content authoring and runtime aspects of engines. Coursework will consist of frequent, tightly-scoped programming and system design assignments; expeditions through game engine source code; and two group projects — one in an engine created from scratch, and one that requires modification of an existing engine. Prerequisites: Students will be expected to be fluent in at least one programming language. We will be working with C++, Javascript, and a smattering of Python. We will be using git for version control and code sharing. The assignments in the course will be designed to be completed on an OSX or Linux workstation (e.g. the IDeATe "virtual cluster"). Working with Windows will be possible, but might require extra effort. We will be building a 3D model pipeline around Blender, but no prior knowledge of the tool will be assumed. Prerequisites: 15-104 or 15-112 or 15-213 or 62-150

16-467 Human Robot Interaction

Spring: 12 units

The field of human-robot interaction (HRI) is fast becoming a significant area of research in robotics. The basic objective is to create and investigate interfaces that enable natural and effective modes of interaction with robotic technologies. HRI is highly interdisciplinary, bringing together methodologies and techniques from robotics, artificial intelligence, human-computer interaction, human factors, interaction design, psychology, anthropology, education, drama, and other fields. This course is primarily lecture-based, with in-class participatory mini-projects, group homework assignments, and a group term project that will enable students to put theory to practice using state-of-the-art interactive robots. The topics covered will include man-machine coupling, underlying robotic technologies, as they relate to human-robot interaction, interaction methodologies and techniques, the singularity, and will include significant discussion of application domains that feature HRI. This course has no prerequisites, but some basic familiarity with robots is recommended (programming knowledge is not necessary, but is useful for the term project).

Course Website: <http://www.cs.cmu.edu/~reids/16-467/>**16-474 Robotics Capstone**

Spring: 12 units

The Robotics Capstone course is intended to enhance the student's capability of professional problem-solving and engineering design skills in robotics. Students taking this course will work in teams to complete a design project to resolve scientific and engineering issues relating to robots. Each team is required to design and build one autonomous robotic system and develop its control algorithm throughout the semester. The class will be composed of lectures and small group meetings. The lectures will discuss the design process and review several subjects of mechatronics (e.g. sensors, actuators, micro-controllers etc.) that will be useful to complete the project. During the weekly small group meetings, students will update their progress and receive feedback on the project. Team participation and communication is important and the presentation and reports must be technical and professional in structure. At the end of the semester, each team is required to make a public presentation of its robot and submit a report that provides clear definition of the problem being addressed, a methodology for the research, literature review, experimental results, conclusions based on findings, and recommendations for future work.

16-597 Undergraduate Reading and Research

Fall and Spring

Missing Course Description - please contact the teaching department.

16-623 Designing Computer Vision Apps

Fall: 12 units

Computer vision is a discipline that attempts to extract information from images and videos. Nearly every smart device on the planet has a camera, and people are increasingly interested in how to develop apps that use computer vision to perform an ever expanding list of things including: 3D mapping, photo/image search, people/object tracking, augmented reality etc. This course is intended for students who are not familiar with computer vision, but want to come up to speed rapidly with the latest in environments, software tools and best practices for developing computer vision apps. No prior knowledge of computer vision or machine learning is required although a strong programming background is a must (at a minimum good knowledge of C/C++). Topics will include using conventional computer vision software tools (OpenCV, MATLAB toolboxes, VLFeat, CAFFE), and development on iOS devices using mobile vision libraries such as GPUImage and fast math libraries like Armadillo and Eigen. For consistency, all app development will be in iOS and it is expected that all students participating in the class have access to an Intel-based MAC running OS X Mavericks or later. Although the coursework will be focussed on a single operating system, the knowledge gained from this class is intended to generalize to other mobile platforms such as Android etc. Strong programming background required.

Course Website: http://www.cs.cmu.edu/~slucey/Design_CV**16-627 MSCV Seminar**

Fall

(Only open to MSCV students.) MSCV students will be required to participate in this one-semester seminar course which will prepare them for the MSCV project starting in the Spring semester. The first part of this course will cover talks by computer vision and related faculty about the ongoing research, development programs related to Computer Vision at CMU. The second part of this course will include student/faculty tutorial on topics such as OpenCV, Dataset Creation, Mechanical Turk etc. The goal of this series is to get students acquainted with practical knowledge for a successful project. In the last month of the course, each lecture will cover up to four possible MSCV projects pitched by faculty or industrial sponsors. At the end of the course students will turn in their choices, and a faculty committee will assign them the final projects.

16-720 Computer Vision

Fall and Spring: 12 units

This course introduces the fundamental techniques used in computer vision, that is, the analysis of patterns in visual images to reconstruct and understand the objects and scenes that generated them. Topics covered include image formation and representation, camera geometry, and calibration, computational imaging, multi-view geometry, stereo, 3D reconstruction from images, motion analysis, physics-based vision, image segmentation and object recognition. The material is based on graduate-level texts augmented with research papers, as appropriate. Evaluation is based on homeworks and a final project. The homeworks involve considerable Matlab programming exercises. Texts recommended but not required: Title: "Computer Vision Algorithms and Applications" Author: Richard Szeliski Series: Texts in Computer Science Publisher: Springer ISBN: 978-1-84882-934-3 Title: "Computer Vision: A Modern Approach" Authors: David Forsyth and Jean Ponce Publisher: Prentice Hall ISBN: 0-13-085198-1

Course Website: <http://www.andrew.cmu.edu/course/16-720/>**16-721 Learning-based Methods in Vision**

Spring: 12 units

A graduate seminar course in Computer Vision with emphasis on using large amounts of real data (images, video, textual annotations, user preferences, etc) to learn the structure of our visual world toward the ultimate goal of Image Understanding. We will be reading an eclectic mix of classic and recent papers on topics including: theories of perception, low-level vision (color, texture), mid-level vision (grouping and segmentation), object and scene recognition, image parsing, words and pictures models, image manifolds, etc. Prereqs: Graduate Computer Vision, 16-720
Prerequisite: 16-720

Course Website: <http://www.cs.cmu.edu/~efros/courses/LBMV07/>**16-735 Robotic Motion Planning**

Intermittent: 12 units

The robot motion field and its applications have become incredibly broad and theoretically deep at the same time. The goal of the course is to provide an up-to-date foundation in the motion planning field, make the fundamentals of motion planning accessible to the novice and relate low-level implementation to high-level algorithmic concepts. We cover basic path planning algorithms using potential functions, roadmaps and cellular decompositions. We also look at the recent advances in sensor-based implementation and probabilistic techniques, including sample-based roadmaps, rapidly exploring random trees, Kalman filtering, and Bayesian estimation.

Course Website: http://voronoi.sbp.ri.cmu.edu/~choset/sbp_class98/sbp_class98.html**16-741 Mechanics of Manipulation**

Fall: 12 units

Kinematics, statics, and dynamics of robotic manipulator's interaction with a task, focusing on intelligent use of kinematic constraint, gravity, and frictional forces. Automatic planning based on mechanics. Application examples drawn from manufacturing and other domains.

Course Website: <http://www.cs.cmu.edu/afs/cs/academic/class/16741-s07/www/index.html>**16-742 Geometry of Locomotion**

Fall: 12 units

This course introduces geometric methods for the analysis of locomoting systems. Focusing on the kinematics of locomoting systems, the course covers topics from differential geometry, geometric mechanics, and motion planning. Specific topics include configuration spaces, manifolds, groups, representations of velocity, holonomic and nonholonomic constraints, constraint curvature, response to cyclic inputs and distance metrics. The primary goal of this class is to develop an intuitive understanding of these concepts and how they are used in locomoting systems, rather than working through a set of formal proofs and derivations. We do, however, incorporate enough mathematical formalism for this class to serve as a starting point for further investigation into this topic area. We also call upon biological data, when available, and relate to the mathematical formalisms in the class.

16-761 Mobile Robots

Spring: 12 units

This course covers all aspects of mobile robot systems design and programming from both a theoretical and a practical perspective. The basic subsystems of control, localization, mapping, perception, and planning are presented. For each, the discussion will include relevant methods from applied mathematics, aspects of physics necessary in the construction of models of system and environmental behavior, and core algorithms which have proven to be valuable in a wide range of circumstances.

Course Website: <http://www.frc.ri.cmu.edu/~alonzo/teaching/16-761/16-761.html>**16-778 Mechatronic Design**

Spring: 12 units

Mechatronics is the synergistic integration of mechanism, electronics, and computer control to achieve a functional system. This course is a semester-long multidisciplinary capstone hardware project design experience in which small (typically four-person) teams of electrical and computer engineering, mechanical engineering and robotics students deliver an end-of-course demonstration of a final integrated system capable of performing a mechatronic task. Throughout the semester, the students design, configure, implement, test and evaluate in the laboratory devices and subsystems culminating in the final integrated mechatronic system. Lectures will complement the laboratory experience with comparative surveys, operational principles, and integrated design issues associated with the spectrum of mechanism, microcontroller, electronic, sensor, and control components.

Course Website: <http://www.ece.cmu.edu/courses/18578>**16-862 Mobile Robot Programming Laboratory**

Fall: 12 units

This course is a complete, hands-on introduction to Mobile Robot Programming. Using six Nomad Scout robots and portable computers, we will survey topics ranging from low-level control and obstacle avoidance, including PID control, to high-level navigation, planning, robot-robot communication and cooperation.

Course Website: <http://www-2.cs.cmu.edu/~illah/teaching.html>

Silicon Valley Courses

96-800 Real World Software Engineering

Intermittent: 24 units

In this twelve week class, your goal is simple: define, design, develop, and release a software app. This is your chance to see what it's like to be an entrepreneur in Silicon Valley, becoming part of a team that creates a startup business. You'll need to hit the ground running as you'll want feedback from users quickly. You'll need to build a team of students with complementary skills, including software engineers and those who understand the business issues. The course will end with pitch day where faculty and investors will evaluate your final product.

Course Website: <http://sm.sv.cmu.edu/spdl>

Social Decision Sciences Courses

88-110 Experiments with Economic Principles

Fall: 9 units

This course is designed to teach the basic principles of economics through the use of experiments. In each experiment you will be an active participant attempting to make deals with other traders in the market. At the end of the experiment it is time to really put economics to the test—can economic theory really explain the complex interactions of the participants in your experiment? One nice feature of these experiments is that you can be both a participant and an observer, and you often will learn nearly as much about economic principles from your experience as a participant as you will from the analysis of the experiment as an observer. Topics covered include basic market behavior, auctions, rent control, pollution, network externalities, information economics, and international trade.

88-114 SDS Freshman Seminar: Everyday Irrationality

Intermittent: 9 units

This seminar will cover the historical progression from belief in hot irrationality—i.e., emotional interference with an otherwise pristine intellect (Plato, Freud) through cold irrationality—i.e., clear thought stymied by common cognitive biases and heuristics (Tversky and Kahneman)—through a possible integration of hot and cold approaches—e.g. resulting from attentional mechanisms (Simon, Loewenstein, Lerner). Then the professor and students will discuss belief in ESP, alternative medicines, faith healing and Nazism in terms of the principles proposed. During the last half of the semester, students will choose a particular irrational belief to study and will both present to other students and write a term paper describing its acceptance (by at least some people) and possible reasons for such acceptance. The major text will be Dawes's new book "Everyday Irrationality: How Pseudo-Scientists, Lunatics, and the Rest of Us Systematically Fail to Think Rationally." This book will be supplemented by selected readings from Plato, Freud, Hines's book on "Pseudoscience and the Paranormal," Gilovich's book of "How We Know What Isn't So," a book of first-hand accounts by the perpetrators of the Holocaust entitled "Death Dealers," and finally Browning's book of "Ordinary Men."

88-115 Risk Communications for Health Decisions

Intermittent: 9 units

This seminar will explore how people make decisions about risk behaviors in various contexts relating to their health, including diet and exercise, sexual behavior, smoking, drinking, drug use, etc. The main focus of the course will be looking at efforts to improve health by educating people to make better decisions about reducing their own health risks. Students will participate in active class discussion, debating the benefits of different approaches to public health. The mid-term project will include basic research and data collection on a health behavior. The final project will include the production and planned evaluation of a public service announcement, aimed at improving health decisions and behaviors. Readings will include book chapters and original research articles relating to the psychology behind such behaviors and trade-offs.

88-117 Social Dilemmas from Overpopulation to Global Warming

Spring: 9 units

Social dilemmas are situations in which a number of people make simultaneous choices between what is roughly termed "cooperative" versus "non-cooperative" behavior where the individual payoffs for the non-cooperative choice are always higher than for the non-cooperative choice no matter what other people involved in the decision do. Yet universal cooperation is preferred to universal non-cooperation by all the people making choices. The first part of the seminar will be devoted to reading the classic theoretical arguments about social dilemmas, and to the surveying some of the empirical findings of social psychologists such as Dawes about what variables other than payoff changes might enhance the probability of cooperative choices, e.g., "identification with the group". After becoming familiar with the theoretical and empirical literature, the members of the seminar will be asked to give presentations concerning either their own ideas or the ideas of some other theorist or investigator about how to enhance the incidence of cooperative choice. Each member of the seminar will be expected to lead one session presenting such ideas and to write a term paper about them.

88-119 Strategy Cooperation and Competition

9 units

When should a person cooperate and when should a person be selfish in an ongoing social interaction? How can a business establish strategic partnerships when it comes to creating a pie and at the same time battle with competitors when it comes to dividing up the pie? Strategic thinking requires a framework to think through the implications of cooperation and of competition. Game theory is a systematic approach to understanding how people, firms, or countries interact with one another to achieve their own goals. In this course students will learn to apply game theory to analyze strategic situations arising in the business world as well as in politics, sports, and international relations. We will discuss how individuals and businesses can shape the games they play to their benefit and how social policies can be implemented to encourage cooperation benefiting everybody. Readings will focus on real-life stories accompanied by a full analysis of the principles involved. Students will give presentations applying these principles to a strategic problem they find engaging. Students will also be placed in the role of strategist in simulations in class.

88-120 Reason, Passion and Cognition

Fall: 9 units

This course will introduce students to major concepts and theories in the social and decision sciences, focusing in particular on how cognition and emotion shape judgment and choice. We will address such questions as: In what ways do emotions influence judgments and choices? What are some common mistakes in judgment and decision making? Can information shape our choices even if we do not consciously recognize the information? Throughout the course, the emphasis will be on understanding: (1) basic theories and research findings of decision science and psychology, and (2) the relevance of research findings to everyday life.

88-125 Freshman Seminar: Forecasting Uncertainty

Intermittent: 9 units

Whenever you make a plan, you have to think about the future. Sometimes you know a lot, sometimes you know very little, and sometimes you know very little but think you know a lot. Amazingly, the same types of errors that you make every day are made by policymakers planning multi-billion dollar options. In this course, we will explore these errors and methods for reducing them. Examples will be drawn from many hot topics including climate change, health care, and government regulation.

88-198 Research Training: Social and Decision Sciences

Fall and Spring

This course is part of a set of 100-level courses offered by H&SS departments as independent studies for second-semester freshmen, and first- or second-semester sophomores, in the College. In general, these courses are designed to give students some real research experience through work on a faculty project or lab in ways that might stimulate and nurture subsequent interest in research participation. Faculty and students devise a personal and regularized meeting and task schedule. Each Research Training course is worth 9 units, which generally means a minimum for students of about 9 work-hours per week. These courses are offered only as electives; i.e., they cannot be applied toward a college or major requirement, although the units do count toward graduation as elective units. Additional details (including a roster and descriptions of Research Training Courses available in any given semester) are available in the H&SS Academic Advisory Center. Prerequisites/restrictions: for H&SS students only; only for second-semester freshmen, or first- or second-semester sophomores; minimum cumulative QPA of 3.0 (at the time of registration) required for approved entry; additional prerequisites (e.g., language proficiency) may arise out of the particular demands of the research project in question.

88-220 Policy Analysis I

Fall: 9 units

This course provides an introduction to theories and methods for policy analysis. The main focus of the course is to develop an understanding of how theories from social science, such as economics, can help us understand policy issues such as allocation, regulation, and welfare. Throughout the course we analyze outcomes produced by private markets, by examining consumer choice, the supply and demand of factors and produced goods, and general and partial equilibrium. We also analyze the efficiency and welfare properties of such outcomes, paying special attention to the role of policy in influencing market outcomes. We consider how policy can address the efficiency and welfare shortcomings of markets that may result from informational asymmetries, industrial organization, moral hazard, transactions costs, and bounded rationality. Markets are compared in this light with organizational, governmental, and other modes of resource allocation. Grading will be based mainly on 3 exams. Homework assignments and/or quizzes will comprise a smaller part of the grade.

88-221 Policy Analysis II

Spring: 9 units

This course is an extension of Policy Analysis I and focuses on a normative analysis of government action. The course begins by considering justifications for government action drawing on work in political philosophy. It then compares different institutional approaches governments may adopt in attempting to correct market failures and in pursuing objectives other than efficiency. The basic concepts and tools of cost benefit analysis are then presented. Students are involved in individual and group projects applying the class material to specific policy issues.

Prerequisites: 88-220 or 73-230

88-223 Decision Analysis and Decision Support Systems

Spring: 9 units

This course emphasizes explicit procedures for analyzing complex decisions. The topics covered include: decision trees and other models of decisions involving uncertainty; methods for quantifying preferences and expert opinion; risk analysis; and the development and use of computerized decision aids ranging from spread sheet programs to highly specialized decision support models.

Prerequisites: 36-207 or 36-201 or 70-207 or 36-247 or 36-220 or 36-225 or 36-211 or 36-217

88-251 Empirical Research Methods

Fall: 9 units

This course teaches students how to evaluate and conduct original research regarding human behavior, whether it be in economic, social, or political settings. The course gives students practical experience in many of the most commonly used research techniques, including surveys, experiments, and quasi-experimental analysis. Although the course focuses primarily on the relationship between formulating research questions and implementing the appropriate methods to answer them, students can expect regularly to apply the statistical techniques learned in the course prerequisites, including regression.

Prerequisites: 36-201 or 36-207 or 36-247

88-252 Causal Inference in the Field: Using Data to Study Crime, Love, Sports & More

Intermittent: 9 units

Causal questions are pervasive in the social and behavioral sciences, and empirical researchers often use regression analysis as a tool for tackling such questions. This course focuses on the scientific problem of analyzing causal hypotheses in real-world settings, not on the mathematical details of regression. After clearly distinguishing prediction from causation, we discuss how to represent causal hypotheses and how to use regressions to analyze both predictive and causal hypotheses. Using in-class data exercises throughout, we will examine how to move from an interesting but somewhat vague question about the world (e.g., do police discriminate based on race and gender, do NFL athletes choke under high pressure, does parenthood improve happiness) to a clear statistical model that, when estimated, meaningfully addresses the question asked. The course emphasizes causal analysis as the main research goal and multivariate linear regression as the main statistical tool. After mastering basic techniques, we will introduce students to more advanced econometric approaches such as panel regressions and instrumental variables to deal with trickier settings in which causal inference is more challenging (e.g., do more guns lead to more violence?). In keeping with the hands-on philosophy of the course, a central focus of the semester will be a group research paper/presentation where students will have the opportunity to formulate and empirically test a research question of their choosing. Students will learn how to find, clean, and analyze a new dataset, and then concisely communicate their findings in the form of a scientific paper (and accompanying presentation). The research project makes this course excellent preparation for any student who hopes to ultimately write an undergraduate thesis.

Prerequisites: 36-201 or 70-207 or 36-207

88-257 Experimental Economics

Fall: 9 units

This course will focus on the experimental literature studying decision-making and strategic interactions. We will explore both seminal and ongoing experimental work on risk, time and social preferences, as well as how these preferences are affected by emotions and other visceral factors. The course will focus on laboratory experiments. The last section of the class will focus on the use of experiments to test economic theory (both standard and behavioral). The class is meant to be interactive, and students will have many opportunities to critically discuss existing experimental research, as well as to present their own research ideas.

88-260 Organizations

Spring: 9 units

Even in a "market" economy, the preponderance of economic activity is carried out through firms and other organizations. The course begins by examining economic theories of the firm, and explores some of the canonical questions, such as why are there firms, how the separation of ownership and control of a firm shapes decision making, what determines the boundary between organizations and markets (e.g., make-or-buy decisions), what types of firms are most innovative, and how new technologies affect organizational structure. A second set of issues concerns how various organizational forms motivate, or fail to motivate, employees. The central concepts will be fleshed out by examining business firms, as well as not-for-profit enterprises, political parties, and government agencies.

88-281 Topics in Law: 1st Amendment

Fall: 9 units

In their firm desire to perfect the new Constitution, which defined and limited the powers and roles of their new government, the founding fathers insisted on explicit statements that would protect the rights of the new nation's citizens. Indeed, the protection of these essential rights in many ways drove and defined their successful rebellion from Britain. This impulse resulted in ten amendments to the Constitution, which we have come to know as the Bill of Rights. The very first (and arguably considered at the time as the most essential) of these was the First Amendment, which we sometimes call the "free speech" amendment to the Constitution. This amendment guarantees every U.S. citizen five freedoms: freedom of religion, speech, press, peaceable assembly, and the freedom to petition the government for redress of grievances. This course examines the historical and philosophical roots of this key constitutional amendment, how it has been fleshed out and defined over time through case law, and the bases of some more recent critics of this amendments and current interpretations.

88-283 Decision Making in Clinical Psychology

Spring: 9 units

This course surveys decision making surrounding core issues in clinical psychology. It includes an overview of how decisions are made in the prediction of mental illness, risk for violence, and the probability of recovery among individuals with mental illnesses. It also investigates decisions surrounding the treatment of mental illness, such as the efficacy of existing treatment methods and discrepancies between professional judgments and actual outcomes. The final section of the course will shift the focus to decision making by individuals with specific disorders. Here we will examine decision making among individuals with addictions, eating disorders, aggressive behavior problems, and neurological illnesses.

88-284 Topics of Law: The Bill of Rights

Spring: 9 units

This course examines the history and place of the Bill of Rights in our nation's constitutional framework. It focuses on the historical origins of the U.S. Constitution, of each of the first ten amendments to the Constitution (that we refer to as the "Bill of Rights"), how the meanings and interpretations of these have evolved over time, and what they mean to us today. Each article of the Bill of Rights will be examined in terms of its original intentions, and then through cases that have challenged and been interpreted through the Bill's articles.

88-302 Behavioral Decision Making

Fall: 9 units

Behavioral decision making is the study of how people make decisions, in terms that can eventually help them to make better decisions. It draws together research from psychology, economics, political science, and management, among other fields. It has applications that range from managing potentially hazardous technologies, to involving patients more fully in the choice of medical procedures, to the design of computer-interactive systems. The course covers behavioral theories of probabilistic inference, intuitive prediction, preference, and decision making. Topics include heuristics and biases in inference and prediction, risk perceptions and attitudes, strategies for combining information from different sources and dealing with conflicting objectives, and the roles of group and emotional processes in decision making. The course emphasizes the mutually reinforcing relationship between theory and application.

Prerequisites: 36-217 or 36-220 or 36-225 or 36-247 or 70-207 or 36-207 or 36-201 or 36-211

88-316 Game Theory

Intermittent: 9 units

Game theory is the branch of decision theory in which decision problems interact. Due to its flexibility and strategic nature, game theory is used heavily in other academic areas such as economics, political science, biology, and even competitive sports. This course will cover those parts of game theory of special interest to social scientists. We will discuss specific elements of the formal theory of games as well as experimental results. Throughout the course we will examine applications of game theory to problems across the social sciences.

88-341 Organizational Communication

Fall: 9 units

Much of the work in groups and organizations consists of communication. You communicate to get information that will be the basis of decisions, to provide a vision for the people who work for and with you, to coordinate activity, and to sell yourself and your work. The goal of this course is to identify sources of communication problems within an organization and ways to overcome them. To do this requires that we know how communication normally works, what parts are difficult, and how to fix it when it goes wrong. The focus of this course is on providing you with a broad understanding of the way communication operates within dyads, work groups, and organizations. This course is not a practicum in public speaking or writing, although you will get some experience writing, speaking and managing impressions. Rather the intent is to give you theoretical and empirical underpinnings for the communication you will undoubtedly do when you return to work. Readings come from both the research and the managerial literatures. Among the topics considered are managerial communication, persuasion and conformity, self presentation and person perception, social networks. Cases and group projects give you an opportunity to apply what you've learned.

Prerequisites: 36-247 or 36-225 or 36-220 or 36-217 or 36-207 or 36-201 or 70-207

88-342 The Neuroscience of Decision Making

Intermittent: 9 units

Because we are human, feelings provide the basis for reason and rational decision-making. Consider for example, that brain-damaged patients left devoid of emotion struggle to make the most elementary decisions: while they are able to layout the pros and cons of a decision, but they are unable to make the final choice. This course will discuss seminal discoveries in affective neuroscience underlying decision-making.

Prerequisites: 85-211 or 88-120

88-343 Economics of Technological Change

Intermittent: 9 units

This course will consider the determination of innovative activity and performance, and the effect of innovation on productivity, economic growth, and social welfare. We will focus particularly on the characteristics of markets and firms that influence industrial innovation. Such characteristics include, for example, market concentration, firm size, the strength of patent protection, and the vitality of the basic science and technology underlying innovation in a given industry. We will also study the economics of the adoption and diffusion of innovation. In addition to drawing on economic theory, the course will emphasize empirical studies of innovation and technological change, and will selectively exploit case study and institutional studies.

Prerequisites: 73-250 or 73-251 or 88-220

88-345 Perspectives on Industrial Research and Development

Intermittent: 9 units

Incandescent and fluorescent electric lights; nylon and Kevlar; the atomic bomb; the transistor and integrated circuits; Post-it; Teflon; Silly Putty; GameBoys; and biopharmaceuticals (from Viagra; and Levitra; to Paxil; and Enbrel;), among a panoply of other consumer and industrial goods, are all products that emerged from organized industrial research and development (R&D) programs. The beginnings of this new institution in the late 19th century, its rapid rise in the first third of the 20th century, its flourishing in the middle third of the 20th century, and its decline and reorganization in the last decades of the 20th century and first decade of the 21st century are the principal focus of this advanced reading seminar. What factors led to the establishment of modern R&D? Why did industrial R&D laboratories appear in the US and other industrialized nations? How did their creation change the character of science, technology, and business? How did the institutionalization of R&D affect the work of individual inventors, engineers, and scientists? Does big business now dominate R&D in the United States, or does "the little guy" (including university-based "start ups") still play an important role in technological innovation? What about the interaction of universities and industrial R&D programs? How has industrial R&D been "managed"? How has federal science and technology policy affected industrial R&D? With the globalization of business, is industrial R&D also becoming global, and if so, how does industrial R&D work on a global scale? Why did the last decade of the 20th century see the decline or disappearance of numerous prestigious industrial research organizations? What is the future of industrial R&D in the 21st century? These are some of the questions explored in this course, which is open to serious students from all colleges.

88-347 Complex Technological Systems: Past, Present, and Future

Intermittent: 9 units

The Internet is only the latest example of a complex technological system that fundamentally alters the way that we act in and think about our world—and about technology itself. During the last two centuries such complex technological systems have emerged, ranging from transportation systems such as the railroad and mass-produced automobiles running on paved roads and superhighways to networked information systems including the telegraph, the telephone, and radio and television. What are the common features of these complex technological systems? When do they emerge? How are national and international standards for these systems established? How far reaching are the consequences of these systems in society, business, and in other complex technological systems? Can they be predicted? Can they be controlled? Can such complex technological systems be fully comprehended and modeled? In a world in which many of these systems are interconnected, how vulnerable are current societies (such as those in the West) that depend on them, especially in an age of global terrorism? These are but some of the questions this lecture and discussion course will tackle using cases from the past, the present, and the future. Students are graded through weekly quizzes, midterm and final examinations, and class participation. Prerequisites: junior or senior standing.

88-352 Environmental Economics and Policy

Fall: 9 units

The course will introduce students to the economic analysis of problems associated with private and collective use of environmental resources and to the analysis of public policy options to environmental problems. Policy relevant examples will be used throughout the course. When thinking about protecting nature environmental economics has traditionally focused on the idea that market failure (externalities, non rival goods, asymmetric information) is the critical source of economic inefficiency. Based on this idea economists have designed policies for environmental protection, which include Pigouvian taxes, marketable permits, liability rules and mechanisms design. We will start from the theories of externalities, market failure and mechanism design, and we shall explore the causes of these problems and some of the potential remedies using the competing/complementary lenses of traditional and behavioral economics. To organize and evaluate alternative environmental policy options environmental economics has traditionally used rational choice theory. According to rational choice theory, people respond to policy instruments in their own self-interests and take all possible consequences into account. Behavioral economics has emerged to challenge this traditional view by documenting how people make choices and state values that deviate from the conventional rationality model. We will try to understand the behavioral economics underpinnings of environmental policy and how understanding the success and failure of conventional economic theory can help make good environmental policy better.

Prerequisites: 73-150 or 88-220

88-355 Social Brains: Neural Bases of Social Perception and Cognition

Intermittent: 9 units

By some accounts, the large expansion of the human brain evolved due to the complex demands of dealing with social others—competing or cooperating with them, deceiving or empathizing with them, understanding or misjudging them. This discussion-based seminar surveys the emerging field of social cognitive neuroscience and its multi-level approach to understanding the brain in its social context. We will review current theories and methods guiding the field and recent research examining the neural bases of social processes, including: theory of mind, empathy, emotion, morality, among others. We will also discuss broader questions that apply to the specific topics that the course covers, including: What are appropriate levels of description for the target phenomena? How can different disciplines in neuroscience and the social sciences contribute to social neuroscience research? What can we learn from animals? behavior about human social cognition? Do neural systems exist that are specialized for social cognition, or do the systems that participate in social cognition have more general cognitive functions?

Prerequisites: 85-310 or 85-340 or 85-355 or 88-251

88-360 Behavioral Economics

Intermittent: 9 units

This course introduces students to behavioral economics, an emerging subfield of economics that incorporates insights from psychology and other social sciences into economics. We will examine evidence on how human behavior systematically departs from the standard assumptions of economics, and then investigate attempts by behavioral economists to improve economic analyses.

Prerequisites: (21-112 or 21-120) and (73-100 or 88-220)

88-363 Behavioral Economics Theory

Intermittent: 9 units

This course offers an introduction to the field of behavioral economics psychology and economics. The goal is to learn how to think about economic decision-making in a psychologically richer way while maintaining the rigor of economic analysis. You will learn (i) what are the basic psychological phenomena that are most important for economics; (ii) how to identify these phenomena from simple decisions and capture them in economic terms; and (iii) how they should change our understanding of basic economic questions.

Prerequisites: (73-100 or 88-220) and (21-112 or 21-120)

88-365 Behavioral Economics and Public Policy

Intermittent: 9 units

Economics has up to now been the social science that has been most broadly and deeply involved in public policy. With its rational choice perspective, the economic perspective has tended to favor certain types of policies namely those that enhance the efficiency of market mechanisms and lower the cost of information. In this course we will spend the first several classes reviewing the assumptions, implications for public policy and limitations of the rational choice perspective. The remainder of the course will then be devoted to examining different public policy issues, including saving, health care, crime and drug abuse, through the competing lenses of traditional and behavioral economics.

Prerequisites: 73-100 or 88-220

88-367 Behavioral Economics in the Wild

Intermittent: 9 units

Behavioral Economics is a sub-field of economics that, relying on insights from psychology and decision-making, aspires to describe actual behavior with greater empirical accuracy and psychological realism than that implied by the standard neoclassical model. In this course, we will investigate the success of this approach in explaining ostensible anomalies in the "wild" such as under-savings for retirement, over-consumption of unhealthy food, extreme aversion to losses among investors, workers, and home-owners, the over-confidence of corporate CEOs and NFL general managers, and the influence of emotions on domestic violence, stock market activity, and risk-taking. We will first document and review the underlying theory for three conceptual departures from the standard model—non-standard preferences (e.g., present-bias, reference dependence), non-standard beliefs (e.g., overconfidence, gambler's fallacy), and non-standard decision-making (e.g., heuristics, emotions, framing effects)—and then quickly move to assess the evidence for these claims in field settings. We will additionally explore how markets respond to behavioral biases, and discuss recent research in behavioral policy with an emphasis on policies aimed at increasing savings, improving food choice, and heightening program take-up and compliance. The course will be paper-centric and we will review a variety of popular empirical methods from field experiments to quasi-experimental approaches (e.g., estimation through regression-based panel analyses, difference-in-differences, and instrumental variables). Student evaluation will be based on performance on problem sets, an exam, as well as a short class presentation of an empirical paper of choice.

Prerequisite: 36-202

88-371 Entrepreneurship, Regulation and Technological Change

Intermittent: 9 units

There is a growing interest in understanding the interrelationships between regulatory institutions and innovations. Certainly, opportunities for innovative activities take place in the context of the extant public policy institutions (e.g., entry restrictions in telecommunications, environmental performance standards, intellectual property protections). Consequently, entrepreneurial activity plays a key role in identifying and exploiting these opportunities. In this course, we examine the role that entrepreneurs play in the interrelationships between regulation and technological change. The objectives are to develop and articulate an understanding of the theory, nature, and role of entrepreneurship in the American economy; the theory, nature, and role of regulation in the American economy; and the theory, nature, and role of the dynamic interaction of entrepreneurship and regulation in the American economy. Students will evaluate historical cases in which new or changing regulation presents opportunity for entrepreneurial entry in business, as well as historical cases in which entrepreneur activity (in the form of innovation) presents new needs or opportunities for regulation, thereby presenting or constraining further opportunities for entry. The course is broken into a series of blocks, and each week there will be a set of readings posted on Blackboard. Blackboard will be used to facilitate communication, including announcements, readings, lectures, and assignments.

Prerequisites: 73-150 or 88-220 or 88-202 or 79-300

88-378 International Economics

Intermittent: 9 units

This course analyzes the causes and effects of commercial and financial transactions between nations and the major policy issues raised by these transactions. The first half focuses on international trade and commercial policy using the tools of microeconomic analysis. The second half deals with balance of payments and exchange rate issues with emphasis on problems of macroeconomic policy in open economies.

88-384 Conflict and Conflict Resolution in International Relations

Intermittent: 9 units

Course will introduce students to concepts of conflict, conflict resolution, and peace in international relations. Causes of war, alliances, and role of non-state actors in conflict will be examined. There will be also discussion on foreign policy decision making, mediation, negotiation and international law. The following specific cases will be discussed the Middle East Peace Process (Security Council Resolution 242, Camp David, Oslo Agreement and Geneva Accord); Indo-Pakistan dispute (Lahore Declaration 1999); War in Bosnia and Herzegovina and the Dayton Peace Accords; El Salvador Peace Agreement (between the Government of El Salvador and the Frente Farabundo Martí para la Liberación Nacional); and the Algiers Agreement between Eritrea and Ethiopia. Globalization, terrorism, and conflict resolution will also be covered.

88-385 Managerial Decision Making

Fall: 9 units

People in organizations make decisions, with important consequences, every day. Therefore, an understanding of decision-making is important in any education in management or economics. However, while a large number of courses in these curricula expose students to how decisions should be made, very few focus on how people actually make choices. This course addresses this topic by focusing on how decisions made by real people - and in particular decisions in business contexts - differ from the theoretical predictions of rational decision-making. We specifically focus on common areas of biased decision-making, their basis, and how they might be corrected. The focus of the course is on both individual and competitive decision-making.

88-386 Desires and Decisions

Spring: 9 units

This course explores how the desirability of experiences and (consumer and public) goods are determined. Through the lens of psychological research we will explore (1) the construction of preferences, (2) how preferences are affected by factors such as context, adaptation, memory, culture, and emotion, and (3) attempt to understand how the malleability of our preferences affects our personal decisions, economic markets, the law, and public policy. Class meetings will include a mixture of lecture and discussion, with a stronger emphasis on discussion. Throughout the course, the emphasis will be on learning to critically evaluate advanced theories and research findings of decision science and psychology, and carefully articulate those critiques orally and in writing.
Prerequisite: 88-120

88-387 Social Norms and Economics

Intermittent: 9 units

Social norms play an important role in individual economic decisions and influence economic exchange outcomes. This raises several important questions. What mechanisms are effective in enforcing social norms? To what extent and in what contexts might we expect norm obedience absent external economic incentives? How should we take into account the role of social norms when designing economic institutions? This course discusses experimental research in economics, law and psychology that takes steps towards answering these and other related questions.

88-388 Psychological Models of Decision Making

Intermittent: 9 units

This course provides an introduction to several techniques and theories for modeling psychological processes and decision making. The topics covered include: signal detection theory, individual decision modeling, and multidimensional scaling. The course will include an introduction to the theory behind the models as well as "hands on" computational applications of the models with data. The topics covered in this course can be used in a variety of applied settings-ranging from medical and public policy to marketing and psychological research-to produce simplified representations of seemingly complex phenomena.
Prerequisites: 36-201 and (21-112 or 21-120)

88-391 Technology and Economic Growth

Fall: 9 units

The importance of economic growth is difficult to overstate. The more than tenfold increase in income in the United States over the last century is the result of economic growth. So is the fact that incomes in the United States and Western Europe are at least thirty times greater than incomes in much of Sub-Saharan Africa. Economic research has clearly identified technological innovation as the engine of long-run economic growth. This course seeks to provide students with analytical frameworks that will enable them to understand the economic growth process, the role that technological innovation plays in that process, and the policies and institutions that can enhance and sustain technological innovation in industrialized societies.

88-398 Independent Study

Fall and Spring

Students conduct independent academic study under the supervision of a Social & Decision Sciences faculty member. Students who wish to engage in an independent study should seek out a faculty member whose interests are appropriate to the topic. Students must also complete an "Independent Study/Research for Credit" form, available from the SDS Coordinator of Student Programs in Porter 208A. Prerequisite: Permission of a faculty sponsor.

88-399 Undergraduate Research

Fall and Spring

Students conduct research under the supervision of a Social & Decision Sciences faculty member. Students who wish to engage in research should seek out a faculty member whose interests are appropriate to the research. Prerequisite: Students must also complete an "Independent Study/Research for Credit" form, available from the SDS Coordinator of Student Programs in Porter 208A. Permission of a faculty sponsor.

88-402 Modeling Complex Social Systems

9 units

Many of the biggest challenges facing modern societies—maintaining global political and financial stability, protecting against terrorist acts, cooperating to solve collective problems such as climate change or corruption—are complex. They are not simply complicated; they arise as interacting agents create various feedbacks that result in, often unintentional, emergent phenomena. Confronting these challenges requires an understanding of the properties of complex systems. In this course, we will provide an overview of complex systems theory and concepts. You will learn the fundamental properties of complex adaptive systems and how to apply these insights to a variety of key social science problems. We will introduce and analyze computational and mathematical models, as well as qualitative models, so you should have some familiarity with basic probability and algebra. We will explore topics such as inequality, networks, information spread, community formation, the evolution of cooperation, and the stabilization of financial markets. We will cross traditional disciplinary boundaries and venture into economics, political science, sociology, finance, cognitive science, computer science, physics, statistics, and mathematics as needed. Students will be expected to think critically about how to apply modeling insights to the real world, taking account of the social, political, and economic implications of proposed policies. They will express their ideas in class discussions, presentations, and written reports. The course will culminate with students engaging in a research project to model a complex social system of their choice.
Prerequisites: 36-220 or 36-225 or 36-247 or 70-207 or 36-201 or 36-207 or 36-217

88-403 Network and Social Systems

Intermittent: 9 units

Modern societies are structured and highly connected systems. The necessity to cope with major phenomena like disease spread, terrorism, organized crime and financial crisis, requires understanding of the fundamental properties of complex (social) networks. In this course, we will first provide an overview of the theory of networks. We will then focus our attention on networks in social sciences and, in particular, on the nature of social links, as the perception of the nature of a social connection may be subjective to some extent. We will learn the basic structural and dynamical properties of networks, and how to apply these concepts to real social systems. We will investigate, starting from real data, the structure of several social networks including phone call and email networks, friendship networks, financial networks, trading networks, and crime networks. We will also explore the dynamics of processes occurring on networks, such as disease spread and market contagion, and macroscopic phenomena related to these processes, including information cascades and herding. Students will be expected to think critically about concepts, models and empirical evidences presented in class. They will also be expected to apply concepts and data analysis tools to real world networks.

88-404 Economics of the Internet and the Digital Economy

Intermittent: 9 units

Networks and information play a major role in the rise of the digital economy, and they are challenging the economic theory. Information goods are "anything that can be digitized". They stem from many industries, from media to creative industries, as well as finance or scientific research. Then, the diffusion and commercialization of information goods rely heavily upon network infrastructures, both technological and social. Hence, information (as software or fluid) and networks (as hardware or pipe) have interdependent economic properties that must be understood jointly to carry out the right economic strategies and policies. In this course, we will study these properties via three perspectives. First, from a user perspective, we analyze what makes the value of information and networks. Second, from a policy maker perspective, we study the various options available to ensure constant innovations and a fair competition. Third, from a firm perspective, we observe how the networked information economy influences innovation and production processes. After this course, you will be able to express a well-reasoned view on questions such as: why is it a battle over smartphone patents? What are the answers to the Internet piracy of creative contents? What are the benefits of open source development?
Prerequisites: 73-100 or 88-220

88-405 Risk Perception and Communication

9 units

Throughout their lives, people make decisions about risks that may potentially affect their health, safety, finances, use of technology, and effects on the environment. This course will review the risk perception and communication literature, focusing on theoretical and methodological issues as well as practical implications for educators, public health officials, engineers, economists, and other experts who aim to teach people about risks. We will discuss how to design surveys to increase our understanding of the problems people face when making decisions about specific risks, and how to design communication materials that help people to improve their decisions. We will highlight examples and applications taken from multiple disciplines, including health psychology, adolescent decision making, environmental science, and engineering.

Prerequisites: 36-225 or 36-247 or 70-207 or 36-220 or 36-217 or 36-207 or 36-201

88-407 Health Risk Communication

9 units

This course will cover the relationship between risk perception and health behavior, focusing on how to effect behavior change through communication. The course will begin by exploring how people make decisions about their health, with an emphasis on how we as researchers can learn what factors affect such decisions. We will then turn to the question of how to change unhealthy behaviors by helping to improve this decision making. Finally, the course will cover strategies for evaluating these techniques, to determine whether they have been effective. Throughout the semester, students will conduct a multi-stage research project, beginning by assessing people's decisions on a health topic of their choice and ending with the creation and production of a health communication intervention and a plan for its evaluation. Readings will consist primarily of original journal articles describing research and reviews, which students will be expected to read prior to class for discussion. Grading will be based on mid-term and final papers describing the research project and on short assignments throughout the semester relating to class readings. This course is aimed at students with a background in Decision Science, Psychology, or related fields. A course on research methods or experimental design is recommended. However, the topic may also be of interest to those studying health or design, and students in these fields are welcome.

88-410 The Global Economy: A User's Guide

Spring: 9 units

In the early years of the 21st Century, nations are more economically integrated than at any other point in human history. This presents business leaders and consumers with unprecedented opportunities and challenges. This course seeks to equip future business leaders to exploit these opportunities and cope with these challenges. The course will accomplish that goal by providing students with a systematic understanding of the fundamental aspects of the global business environment that influence business decisions and behavior. Managers must understand the structural economic factors that determine locational advantages, the way government policies both promote and restrain the integration of national economies with the global economy, and the impact of volatility in the global macroeconomic environment on international business strategy. These issues will be studied using the analytical tools and concepts of international economics, and case studies will be used to relate these concepts to actual business problems. We will also invite international business managers to share their practical experience and insight at several points over the course of the semester.

Prerequisites: 88-220 or 73-100

88-411 Rise of the Asian Economies

Spring: 9 units

For most of the past quarter century, no region of the world has been more economically dynamic than Asia. This course is designed to provide students with the essential knowledge necessary to evaluate opportunities and risks in Asia. The course will use analytical tools drawn from economics and finance, business cases, and guest lectures to focus on the key strengths that sustained economic growth in East Asia for decades, the weaknesses that undermined that growth in the late 1990s, and what lies ahead. The course will also examine Indian economic growth since the early 1980s, and compare India's experience with that of the East Asian economies. A special focus will be placed on recent developments in India and China and the prospects for continued growth in those countries over the next decade.

Prerequisites: 73-150 or 88-220 or 73-100

88-412 Energy, Climate Change, and Economic Growth in the 21st Century

Spring: 9 units

The scientific community has concluded that human industrial activities are causing global temperatures to increase. Coping with the environmental, economic, and political consequences of this change is considered by many to be the preeminent public policy challenge of the 21st century. In this course, we will investigate the basic science of climate change, the prospective economic impact of global warming, the uncertainty involved in long-run climate forecasting, and the technological alternatives available to us as we seek to mitigate the impact of human industrial activity on global warming. The heart of this course will be an in-depth analysis of the policy options available to the United States and the global community. We will investigate the economic costs of these options and the way political realities are likely to shape and constrain policy at the national and international levels.

Prerequisites: 88-220 or 73-150 or 73-100

88-413 Energy and Climate: History, Science, Technology, & Policy in the US 1776-2076

Intermittent: 9 units

This course provides CMU students with a historically grounded, technically informed, and policy-centered examination of energy and climate in the United States from the American Revolution to the nation's tri-centennial, by which time the nation will either have taken the necessary action to avoid massive catastrophes related to global warming or will be destined for—and perhaps already experiencing—a series of vastly catastrophic climate events that visit apocalyptic-like suffering and misery on large segments of the nation. Energy procurement and expenditure in the US and climate change have been surprisingly linked over the nation's entire. Now is the time for CMU students to understand these relationships historically, technically and scientifically, and politically and geopolitically. The course is structured around the reading and discussion of landmark scholarship on energy and climate sewn together by lectures, films, and various unorthodox pedagogical methods.

88-415 Global Competitiveness: Firms Nations, and Technological Change

9 units

This course introduces students to the fundamental principles surrounding global competitiveness and technological change in the 21st century. The past twenty years have seen dramatic changes in innovation ecosystems in the U.S. and internationally. Alone within the U.S., there has been a sharp decline in corporate R&D labs, matched by the global fragmentation of firm activities. At the same time growing linkages have been observed across institutional firms, government labs, and universities and national borders. These changes raise critical questions about the new rules of the game driving technological change in the 21st century. This course sheds insights into these questions through the lenses of competing economic, sociological, and political science theories on the structures supporting technological change. The course is broken into three sections. The first section introduces students to theories of the firm, bureaucracy, institutional economics, and social networks as competing frameworks within which to understand technological change. The second section presents the contemporary literature on the technological change, including creative destruction, dominate designs, industry life cycles, and networks of innovators. The concluding section leverages lessons from the preceding two sections to evaluate national innovation systems, and the factors that lead to national comparative advantage. Students should leave the class able to reflect competently on what the existing literature tells us about the factors influencing global technology competitiveness, and on how modern changes in the structures supporting innovation as well as technology itself may be changing the rules of the game for firms and for nations. The course is open to seniors; also to juniors with instructor permission.

88-419 Negotiation

9 units

Negotiation is a process in which two or more parties undertake a process to resolve conflicting interests. Decision makers use negotiation in a variety of circumstances to reach agreements among countries, among employers and employees, among firms, and among family and friends. There are two different sections of this course (students are not permitted to take both): Domestic section: The objective of this course is to understand the process of negotiations and how the structure of the negotiation environment affects the outcomes achieved. Students will learn to analyze the features of the negotiation environment, develop an understanding of effective negotiation strategies, and identify the barriers to reaching wise agreements. This course will focus on negotiations in a wide variety of context: public policy negotiations, business negotiations, and interpersonal negotiations. International section: The objective of this course is to understand the process of negotiations and how the structure of the negotiation environment affects the outcomes achieved. Students will learn to analyze the features of the negotiation environment, develop an understanding of effective negotiation strategies, and identify the barriers to reaching wise agreements. This course will focus on negotiations in primarily international contexts.

88-421 Emotion: Physiology, Neurobiology, Expression, and Decision Making

Intermittent: 9 units

This course examines advanced topics in emotion from a psychological perspective. Emotions are thought to relate to numerous response channels including physiology, neurobiology and expression (facial and vocal), and each of these components and their relationships will be examined. Class will center around discussion of primary sources.

Prerequisites: 85-211 or 88-120

88-423 Institutions, Entrepreneurship, and Innovation

Spring: 9 units

Institutional environment and public policy greatly affect incentives determining the direction of entrepreneurial activity and innovation that are the engines of economic growth. In societies with poor institutions, entrepreneurial talent is mostly directed towards seeking rents rather than generating productive innovations. But even in modern capitalist economies entrepreneurial activity and innovation are strongly influenced by public policies, for example, those related to intellectual property rights. This course seeks to provide students with analytical frameworks that will enable them to understand how various formal and informal institutional arrangements and public policy decisions influence entrepreneurial activity and innovation and how this, in its turn, affects economic efficiency and growth potential of nations.

88-424 Decision Theory and Rational Choice

Intermittent: 9 units

Introduction to the concept of rational choice and its relevance (benefits and limitations) as a tool to analyze different decision problems. Judgment and analysis of decisions by presenting a contrast between the rational choice model from economics and many documented biases and mistakes that can depart from the aforementioned rational model. Topics include rational preferences and optimal choice, judgment and choice biases, mistakes in analyzing statistical data, and basic theories of decision-making under risk and uncertainty.

Prerequisites: 21-120 or 21-112

88-432 International Policy Decision Modeling Workshop

Intermittent: 9 units

Creating and "exercising" mathematical analysis in ways that inform policy and decision making is an art. One can acquire some relevant skills by taking "methods" classes or by reading and discussing case studies describing others' models, but true mastery comes only with practice, notably practice starting with a blank sheet of paper and creating one's own analysis from scratch. This course offers students the chance to practice that art in a "high-feedback" environment. The primary goal is to improve modeling judgment (e.g., good sense about what should be included or excluded from a model or analysis), creativity (practice creating models from whole cloth), and strategy (weaving analytical insights into a coherent decision-relevant "story"). Students will also be taught some basic analytical frameworks and techniques applied to real world policy analysis problems in the international trade and investment policy domain. Using these skills, students will undertake policy analysis projects for U.S. federal government trade policy agencies, potentially including the United States Trade Representative. The instructor, Lee Branstetter, will draw upon his own policy experience in teaching the course and leading student policy analysis. From August 2011-July 2012, Professor Branstetter served as the Senior Economist for International Trade and Investment Issues on President Barack Obama's Council of Economic Advisers.

88-435 Decision Science and Policy

Intermittent: 9 units

Research in the social sciences has extensively investigated how decision makers behave when they encounter many different and difficult decision scenarios. This course serves as an introduction to how relevant research from decision and social sciences can be applied to complex environments such as those encountered by governments (intelligence and policy analysts) and private industry (business strategists and information officers). Topics of operations research, game theory, signal detection theory, and decision theory (heuristics and biases) will be discussed with respect to the application of these theories to improve the performance of individuals and groups within a complex social system.

88-442 Decision Science in Intergroup Conflict

All Semesters: 9 units

A conventional course on decision science tackles the biases and heuristics that affect individual decision-making. This course will highlight biases and heuristics in an intergroup rather than individual context, and in times of uncertainty or insecurity (e.g. conflict) rather than times of stability. Themes to be covered include: intergroup identities, perceptions, emotions, attributions, empathy, moral judgments, sacred values and parochial altruism. The course will draw on a variety of scientific methods (e.g. field & lab experiments, fMRI, and psychophysiology) and disciplinary approaches (e.g. decision science, anthropology, social/cognitive/cultural psychology, and political science). Emphasis will be placed on understanding the relevance of research findings for everyday life.

88-444 Public Policy and Regulation

Intermittent: 9 units

Regulations are a significant policy tool of government. How society and the economy will react to new regulations can be hard to predict. Unintended side effects sometimes occur resulting in costs exceeding estimates and/or benefits never being realized. This course will review the basics of regulatory policy and using historical examples, will explore the reasons why past regulations have succeeded and failed. The second half of the course will involve 2-3 detailed case studies. Quantitative methods will be used to evaluate several pending regulations for real-world clients from both government and industry perspectives.

88-451 Policy Analysis Senior Project

Spring: 12 units

Students in this course apply the research and analytical methods learned in their other courses to a real-world problem. Students decide how to structure the problem, divide into teams responsible for its different parts, identify and analyze relevant literature, collect data, synthesize their results, and present their conclusions in oral and written form to a review panel of individuals concerned with the problem. Faculty members help them along the way. Performance is based on students' contribution to the process and substance of the class, as observed by the faculty and by their fellow students. One or two such projects is offered every term. A complete list of previous topics is available from the department. Course is open only to seniors in SDS.

88-452 Policy Analysis Senior Project

Fall: 12 units

Students in this course apply the research and analytical methods learned in their other courses to a real-world problem. Students decide how to structure the problem, divide into teams responsible for its different parts, identify and analyze relevant literature, collect data, synthesize their results, and present their conclusions in oral and written form to a review panel of individuals concerned with the problem. Faculty members help them along the way. Performance is based on students' contribution to the process and substance of the class, as observed by the faculty and by their fellow students. One or two such projects is offered every term. A complete list of previous topics is available from the department. Course is open only to seniors in SDS.

88-499 Advanced Undergraduate Research

Fall and Spring

Students conduct research at an advanced level under the supervision of a Social & Decision Sciences faculty member. Students who wish to engage in advanced research should seek out a faculty member whose interests are appropriate to the research. Students must also complete an "Independent Study/Research for Credit" form, available from the SDS Coordinator of Student Programs in Porter 208A. Prerequisite: Permission of a faculty sponsor.

88-505 Undergraduate Internship

All Semesters

An internship is an approved and monitored work experience than can be related to an academic field of study through active reflection and specific learning goals. Students must work at least 10 hours per week for the semester at the internship. Additionally, students will also keep in regular contact with a faculty member in Social and Decision Sciences, who will assign and evaluate academic work. Internships are available for 3, 6, or 9 units, depending on the type and amount of academic work produced. Students are responsible for finding their own internships and faculty sponsors, although assistance is available in the department.

Software Engineering Courses

17-400 Electronic Voting

Fall: 12 units

After the punched-card disaster in Florida in 2000, the U.S. has been rushing to replace old voting equipment with direct-recording electronic (DRE) machines (sometimes incorrectly lumped together as "touchscreens"). Recent examination of these machines by computer security experts has revealed significant security vulnerabilities, leading to a call by some computer scientists to either discontinue use of such machines or equip them with a printing device that would enable the voter to see a paper record of how she had voted before leaving the voting booth. This "voter-verifiable paper trail" idea has polarized the voting community, leading to bills in Congress and in some states to require it but with vendors, election officials and public advocacy groups strongly in opposition. Each meeting will be devoted to a technical lecture followed by an hour of general discussion. The course is open to juniors, seniors and graduate students. Students from outside SCS are welcome. No advanced technical background is required except for some security and cryptography topics. Each student will participate in a team project, with a presentation to be made on the last day of the course. Grading will be based on class participation, the project paper and a final exam. There will be assigned readings but no midterm or written homework. This course counts as an elective in the Computation, Organizations and Society (COS) Ph.D. program. Topics include: Voting history and administration, vote buying, election rigging, punched cards, optical scanning, DRE machines, paper trails & Internet voting

Course Website: <http://euro.ecom.cmu.edu/program/courses/tcr17-803>**17-413 Software Engineering Reflection**

Fall: 6 units

This course is an opportunity to reflect on a software engineering experience you have had in industry. It is structured as a writers workshop, in which you will work with the instructor and other students to identify and flesh out a software engineering theme that is illustrated by your industry experience. You will prepare a 10-page report on this theme, comparable to a practitioner's report at a conference like ICSE or OOPSLA, and a 30-minute presentation to match. This course fulfills a requirement of the Software Engineering Minor program, but students in other programs may take the course if they meet the prerequisite industry experience and if space is available.

17-607 Predictable Professional Performance

Intermittent: 9 units

The student will learn to apply the disciplined concepts introduced in PSP by using an agile cyclic development method to create a GUI-based application. While developing the product the student will work in teams to reinforce data collection through a series of ten increments and will learn to estimate using their own data as well as the data of other engineers and will learn to use those estimates to improve their project work. The student will learn how to move quickly through development cycles and will be introduced to shorthand notations for design, learn more about various techniques for development in practice, and will explore technology adoption issues. A special focus will be made on continuous risk management and a more disciplined approach to the capture, analyzing, and making decisions by means of statistical methods. All the techniques, developed interactively with the students, will reinforce the basic concepts from PSP and TSP, but will allow the student to further evaluate their processes and to use the processes in a disciplined team environment with a well understood data collection method. The course will culminate with the student evaluating their own performance as a team member and as a developer in a final report. This course will both reinforce and develop the concepts from PSP and TSP so no prerequisite for either of these courses is needed other than software programming skills producing standalone GUI applications in Java.

17-609 Global Software Development

Intermittent: 9 units

Software development is increasingly a globally-distributed undertaking. The search for talent across national boundaries and the integration of groups thrown together by mergers and acquisitions are but two of the many forces conspiring to fundamentally change the organizational context of software development. The skills that allow developers and managers to thrive in this milieu are among the most important in today's development organizations. Distributed software development organizations are also receiving attention from researchers interested in communication, collaboration, and coordination over distances. Creating trust, awareness, shared understanding, and many other essentials of teamwork typically relies on face to face interaction. Creating effective technology-mediated mechanisms to support distributed teams requires a deep understanding of how individuals come together to form teams and organizations. This course covers a set of topics that are essential to both professionals who will become participants and leaders in globally-distributed projects, as well as researchers interested in studying virtual teams, distributed organizations, and global software development. Topics covered in this course will include: * Virtual teams, distributed organizations * Architectures and coordination * Distributed development environments * Lessons from open source * Open source ecologies * Challenges of culture * The outsourcing relationship * Facilitating trust, cooperation, social capital * Social networks and knowledge networks * Communication and awareness * Assessing coordination risk

17-615 Software Process Definition

Intermittent: 9 units

A software process definition is the cornerstone of implementing and improving a software process. The objective of this course is to prepare students to understand how processes work within the context of an operational, day-to-day engineering company, and most importantly how they can, as an individual within an engineering environment, change a process for the betterment of all. Although the focus is on software process, this course will be useful to all students who will be executing, improving, or defining most any type of process. An incremental methodology and modular approach to software process definition is used and covers: * guidelines for early success and building a sound foundation * organizing the process definition as it develops * approaches to avoid unnecessarily elaborate or formal notations * developing the process using organizational goals and constraints * using the environmental context that the process resides within and builds upon Although the focus is on software process, this course will be useful to all students who will be executing, improving, or defining most any type of process. Requirement: This course is intended for individuals who have operational software engineering experience or a comprehensive undergraduate coursework in software engineering.

17-619 Introduction to Real-Time Software and Systems

Intermittent: 12 units

Introduction to Real-Time Software and Systems presents an overview of time as it relates engineering complex systems. Any system that responds at the pace of relevant events has real-time constraints whether the timescale is short, like the flight controls for an aircraft, or longer, like the flight reservation system for an airline. Fundamental concepts, terminology, and issues of real-time systems are introduced in this course. The focus is on software solutions to real-time problems-solutions that must be both correct and timely. Software development is examined with emphasis on real-time issues during each phase of the software lifecycle. Real-time requirements analysis, architecting real-time systems, designing and modeling system timing, and implementation and testing strategies are studied. Modeling techniques using UML 2.0 are applied. Particular emphasis is placed on real-time scheduling to achieve desired timing, reliability, and robustness. Languages and operating systems for real-time computing, and real-time problems in concurrent and distributed systems are explored. This course provides a comprehensive view of real-time systems with theory, techniques and methods for the practitioner. After successfully completing this course, the student will be able to identify constraints and understand real-time issues in system development, and propose approaches to typical real-time problems. The aim of this course is to motivate and prepare students to pursue more in-depth study of specific problems in real-time computing and systems development. REQUIREMENT: Proficiency with a high-level programming language such as C or Ada and basic concepts of computing systems. Familiarity with software engineering concepts and system development lifecycle.

17-628 The Modern CIO

Fall: 6 units

In today's competitive marketplace, technology can deliver the decisive edge as a company interfaces with its existing customers, engages prospective clients, and communicates across internal, local, national and global channels. Chief Information Officers of successful companies must possess skills that reach beyond the technical realm. Research indicates that competence in the areas of business acumen, communication, financial knowledge, project and board management far surpasses the need for technical competence. This course focuses on the non-technical aspects of 'the corner office'. If the CTO is to be a true strategic business partner with others in the C-suite (CEO, COO, CFO), it is essential that he or she has a grasp not only on technology, but also on the company's core philosophy, business strategy and drivers. This course will capitalize on the technical knowledge acquired in the Master of Software Engineering Professional Programs, and using it to target high-level job opportunities.

17-634 SE Elective

Intermittent

The goal of this course is to provide an understanding of electronics for students with formal backgrounds in computer science and software engineering to prepare them for work in domains where hardware and software are closely coupled. Example domains include: robotics, avionics, automotive, mobile devices, network switching systems, process/environmental controls, and many others. Throughout the course, students will have opportunities to experiment with hardware and software in hands-on exercises that include electronics labs, robotics, process control, and others. Prerequisites: A hardware background is not required, but students should have a solid computer science background that includes languages, data structures, operating systems, and basic computer organization. Real-world project experience is preferred, although academic project work or internships will suffice. Undergraduates are welcomed but instructor approval is required (lattanze@cs.cmu.edu).

17-635 Software Measurement

Fall: 9 units

Sections D and PP are NOT available for on-campus students. The purpose of this course is to introduce students to software measurement — from need identification through analysis and feedback and into the process. Much of the course material demonstrates concepts of software measurement that are used by managers and practitioners in industry today. The course is taught within the framework of the software engineering process. Required text: Selected Readings handed out in class Requirement: This course is intended for individuals who have industrial software engineering experience with a large project, or a comprehensive undergraduate course in software engineering.

17-643 Hardware for Software Engineers

Intermittent

The goal of this course is to provide an understanding of electronics beyond the average computer organization course. Its purpose is to enable software engineers to be more effective in domains where software and hardware are closely coupled. Examples of such domains include robotics, avionics, automotive, process control, and many others. Students successfully completing this course will be better prepared to communicate with hardware-oriented engineers, understand the hardware environment, and the subtle regions where software and hardware meet. Requirement: Students need not have a hardware background, but they should have a solid computer science background including languages, data structures, discrete math, operating systems, and computer organization. It is highly desirable that students have project experience, preferably real-world experience, although project course work and/or internships will suffice. Undergraduates need instructor approval (lattanze@cs.cmu.edu).

17-648 Engineering Data Intensive Scalable Systems

Intermittent: 12 units

Internet services companies such as Google, Yahoo!, Amazon, and Facebook have pioneered systems that have achieved unprecedented scale while still providing high level availability and a high cost-performance. These systems differ from mainstream high performance systems in fundamental ways. They are data intensive rather than compute intensive as we see with mainstream super computers spending the bulk of their time performing data I/O and manipulation rather than computation. They need to inherently support scalability, typically having high reliability and availability demands as well. Given that they often operate in the commercial space the cost-performance of these systems needs to be such that the organizations dependent on such systems can turn a profit. Designing and building these systems require a specialized set of skills. This course will cover the set of topics needed in order to design and build data intensive scalable systems. In this domain engineers not only need to know how to architect systems that are inherently scalable, but to do so in a way that also supports high availability, reliability, and performance. Given the large distributed nature of these systems basic distributed systems concepts such as consistency and time and synchronization are also important. These systems largely operate around the clock, placing an emphasis on operational concerns. This course will introduce students to these concerns with the intent that they understand the extent to which things like deploying, monitoring, and upgrading impact the design. The course will be a hands-on project oriented course. The basic concepts will be given during the lectures and applied in the project. The students will gain exposure to the core concepts needed to design and build such systems as well as current technologies in this space. Class size will be limited.

17-651 Models of Software Systems

Fall: 12 units

Scientific foundations for software engineering depend on the use of precise, abstract models for describing and reasoning about properties of software systems. This course considers a variety of standard models for representing sequential and concurrent systems, such as state machines, algebras, and traces. It shows how different logics can be used to specify properties of systems, such as functional correctness, deadlock freedom, and internal consistency. Concepts such as compositionality, abstraction, invariants, non-determinism, and inductive definitions are recurrent themes throughout the course. After completing this course, students will: 1. Understand the strengths and weaknesses of certain models and logics including state machines, algebraic and process models, and temporal logic; 2. Be able to select and describe appropriate abstract formal models for certain classes of systems, describe abstraction relations between different levels of description, and reason about the correctness of refinements; 3. Be able to prove elementary properties about systems described by the models introduced in the course; and 4. Understand some of the strengths and weakness of formal automated reasoning tools. Prerequisites: Undergraduate discrete math including first-order logic, sets, functions, relations, and simple proof techniques such as induction. Sections D, PP and G are NOT available for on-campus students. Admission to the class is by approval from the instructor: If you are not MSE/MSIT-SE/MITS, send email to garlan@cs.cmu.edu for permission to enroll. The email should briefly describe your background, whether you have taken an undergraduate discrete math course, and why you would like to take the course. The course must be taken for a letter grade (not pass/fail). This is a graduate level course.

Course Website: <http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/17651-f01/www/>

17-652 Methods: Deciding What to Design

Fall: 12 units

Sections D and PP are NOT available for on-campus students. Practical development of software requires an understanding of successful methods for bridging the gap between a problem to be solved and a working software system. In this course you will study a variety of ways of understanding the problem to be solved by the system you're developing and of framing an appropriate solution to that problem. After completing this course, you will be able to: identify different classes of problems and their structures; analyze technical, organizational, usability, business, and marketing constraints on solutions; apply engineering approaches to frame solutions; understand how your understanding of the problem should be reflected in the software design. PREREQUISITE: minimum of 3 months hands-on software development experience in industry. Students not accepted into the MSE program must present a current resume showing relevant industrial experience to department coordinator. This course is offered to only MSE/MITS and MSIT-SE students for fall semester. This course is for graduate students only. This course is for letter grade only (no pass/fail grades). To register for Methods course, you will need a requirement of a minimum of 3 mos hands-on software development experience in industry. Please submit a statement that gives the company, the dates, and a sentence or two about what you were actually doing during that time (i.e. programming, testing, other things actually involved in software development) to jdjh@cs.cmu.edu. This is a graduate course. Only undergrad SE minors may take this course.

Course Website: <http://spoke.compose.cs.cmu.edu/methods-fall-05/res/bib.htm>

17-653 Managing Software Development

Fall: 12 units

Sections D, F, PP and G are NOT available for on-campus students. Large scale software development requires the ability to manage resources - both human and computational - through control of the development process. This course provides the knowledge and skills necessary to lead a project team, understand the relationship of software development to overall product engineering, estimate time and costs, and understand the software process. After completing this course, students will: 1. be able to write a software project management plan, addressing issues of risk analysis, schedule, costs, team organization, resources, and technical approach 2. be able to define the key process areas of the Capability Maturity Model and the technology and practices associated with each and a variety of software development life cycle models and explain the strengths, weaknesses, and applicability of each 3. understand the relationship between software products and overall products (if embedded), or the role of the product in the organizational product line 4. understand the legal issues involved in liability, warranty, patentability, and copyright 5. understand the purpose and limitations of software development standards and be able to apply sensible tailoring where needed 6. be able to use software development standards for documentation and implementation 7. be able to apply leadership principles 8. be able to perform requirements elicitation REQUIREMENT: Students must have had industrial software engineering experience with a large project, or a comprehensive undergraduate course in software engineering. This course is for letter grade only. Contact the instructor (droot@cs.cmu.edu) for permission to join the class. This is a course for graduate students. Only undergrad SE minors may take this course.

17-654 Analysis of Software Artifacts

Spring: 12 units

Analysis is the systematic examination of an artifact to determine its properties. This course will focus on analysis of software artifacts— primarily code, but also including analysis of designs, architectures, and test suites. We will focus on functional properties, but also cover non-functional properties like performance and security. In order to illustrate core analysis concepts in some depth, the course will center on static program analysis; however, the course will also include a breadth of techniques such as testing, model checking, theorem proving, dynamic analysis, and type systems. The course will balance theoretical discussions with lab exercises in which students will apply the ideas they are learning to real artifacts. After completing this course, students will: * know what kinds of analyses are available and how to use them * understand their scope and power, when they can be applied and what conclusions can be drawn from their results * have a grasp of fundamental notions sufficient to evaluate new kinds of analysis when they are developed * have some experience selecting and writing analyses for a real piece of software, applying them and interpreting the results Ph.D. students taking the 17-754 version of the course will gain a broad overview of the analysis research literature and in-depth knowledge of a particular sub-area through a course project. Requirement: A recent discrete math course and programming experience. Strongly Recommended: Models of SW Development course (17-651) before taking this course. This course is for letter grade only (no pass/fail grades). This is a graduate course. Only undergrad SE minors may take this course with the instructor's permission.

Course Website: <http://www-2.cs.cmu.edu/~aldrich/courses/654/>

17-655 Architectures for Software Systems

Spring: 12 units

Successful design of complex software systems requires the ability to describe, evaluate, and create systems at an architectural level of abstraction. This course introduces architectural design of complex software systems. The course considers commonly-used software system structures, techniques for designing and implementing these structures, models and formal notations for characterizing and reasoning about architectures, tools for generating specific instances of an architecture, and case studies of actual system architectures. It teaches the skills and background students need to evaluate the architectures of existing systems and to design new systems in principled ways using well-founded architectural paradigms. After completing this course, students will be able to: 1. describe an architecture accurately 2. recognize major architectural styles in existing software systems 3. generate architectural alternatives for a problem and choose among them 4. construct a medium-sized software system that satisfies an architectural specification 5. use existing definitions and development tools to expedite such tasks 6. understand the formal definition of a number of architectures and be able to reason about the properties of those architectures 7. use domain knowledge to specialize an architecture for a particular family of applications REQUIREMENT: Experience with at least one large software system, either through industrial software development experience or an undergraduate course in software engineering, compilers, operating sys., or the like. This course is for letter grade only. Instructor wants each student who wants to take his Architectures class to have worked on a significant software system in your courses or in industry. Write to (garlan@cs.cmu.edu) for admission into the course stating the experience you have had. This is a graduate course. Only undergrad SE minors may take this course

17-664 Enterprise Application Integration

Intermittent: 12 units

Modern business enterprises are supported by hundreds of disparate applications that work together to achieve a common goal. These applications are typically large three-tier (or n-tier) application silos developed to support a particular facet of business. Unfortunately, in most cases these systems were never designed to have their services reused transparently across an organization. The result is often a lack of flexibility for large-scale reuse, lack of reliability when integrated, inappropriate security models for organization-level integration, and others. Enterprise Application Integration is a graduate-level course on how to design and deploy large-scale systems for supporting the critical backbone of an organization. Although a particular emphasis is put on Service Oriented Architecture (SOA) and Enterprise Service Bus (ESB), a broad set of topics is covered. These include security for large-enterprise systems, reliability for distributed long-running transactions, standards for intra- and extra-organization system integration, deployment and fault-tolerance of systems, and others. The aim of the course is to prepare future software architects to pragmatically deal with large-scale systems, so as to understand the trade-offs and implications of supporting the goals of an organization. PP section for Portugal students only.

17-690 Seminar in Software Process

Intermittent

The Seminar in Software Process course is a self-study and discussion course. Discussions center on how to implement effective and efficient software processes. The focus of the seminar is on systematic approaches to building software better, faster, and cheaper. A variety of process improvement and quality management strategies are discussed, including Total Quality Management, Baldrige Award, ISO 9001, ISO 15504 (SPICE), and others, but the course is primarily structured around the staged approach to improvement from the Capability Maturity Model (CMM). Specific topics that are covered included software project management, configuration management, quality assurance, organizational learning, process definition, training, peer reviews, team building, change management, measurement, and statistical process control. These topics are addressed from a process management perspective. Required Textbook: M.B. Chrissis, M.D. Konrad, and S. Shrum, "CMMI: Guidelines for Process Integration and Product Improvement, Second Edition," Addison-Wesley, 2006, or you can use the online SEI technical reports, which are free. Note that the third edition of this book is planned for March 2011. This is a graduate course. Only undergrad SE minors may take this course.

17-803 Electronic Voting

Fall: 12 units

After the punched-card disaster in Florida in 2000, the U.S. has been rushing to replace old voting equipment with direct-recording electronic (DRE) machines (sometimes incorrectly lumped together as "touchscreens"). Recent examination of these machines by computer security experts has revealed significant security vulnerabilities, leading to a call by some computer scientists to either discontinue use of such machines or equip them with a printing device that would enable the voter to see a paper record of how she had voted before leaving the voting booth. This "voter-verifiable paper trail" idea has polarized the voting community, leading to bills in Congress and in some states to require it but with vendors, election officials and public advocacy groups strongly in opposition. Each meeting will be devoted to a technical lecture followed by an hour of general discussion. The course is open to juniors, seniors and graduate students. Students from outside SCS are welcome. No advanced technical background is required except for some security and cryptography topics. Each student will participate in a team project, with a presentation to be made on the last day of the course. Grading will be based on class participation, the project paper and a final exam. There will be assigned readings but no midterm or written homework. This course counts as an elective in the Computation, Organizations and Society (COS) Ph.D. program. Topics include: Voting history and administration, vote buying, election rigging, punched cards, optical scanning, DRE machines, paper trails & Internet voting

Course Website: <http://euro.ecom.cmu.edu/program/courses/tcr17-803>

Statistics Courses

36-149 Freshman Seminar: Genomics in the Era of Personalized Medicine

Intermittent: 9 units

Our knowledge of the genetic basis for disease has increased dramatically in recent years. As a result medicine is about to undergo a major revolution. In short, the era of personalized medicine is upon us. In this seminar we will explore cutting-edge science in genomics with an emphasis on how this information can be used to calculate the probability of risks. This information serves as a guide in personal choices about our future health. In the process, we will explore recent findings about cancer, obesity, aging and autism. We will visit uplifting case studies of how people benefited from knowledge gained by genetic screening, as well as considering the sharp limitations of direct-to-consumer DNA testing.

36-201 Statistical Reasoning and Practice

All Semesters: 9 units

This course will introduce students to the basic concepts, logic, and issues involved in statistical reasoning, as well as basic statistical methods used to analyze data and evaluate studies. The major topics to be covered include methods for exploratory data analysis, an introduction to research methods, elementary probability, and methods for statistical inference. The objectives of this course are to help students develop a critical approach to the evaluation of study designs, data and results, and to develop skills in the application of basic statistical methods in empirical research. An important feature of the course will be the use of the computer to facilitate the understanding of important statistical ideas and for the implementation of data analysis. In addition to three lectures a week, students will attend a computer lab once a week. Examples will be drawn from areas of applications of particular interest to H&SS students. Not open to students who have received credit for 36-207/70-207, 36-220, 36-225, 36-625, or 36-247.

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-202 Statistical Methods**

Spring: 9 units

This course builds on the principles and methods of statistical reasoning developed in 36-201 (or its equivalents). The course covers simple and multiple regression, analysis of variance methods and logistic regression. Other topics may include non-parametric methods and probability models, as time permits. The objectives of this course is to develop the skills of applying the basic principles and methods that underlie statistical practice and empirical research. In addition to three lectures a week, students attend a computer lab once week for "hands-on" practice of the material covered in lecture. Not open to students who have received credit for: 36-208/70-208, 36-309. Students who have completed 36-401 prior to 36-202 will not receive credit for 36-202.

Prerequisites: 36-220 or 36-207 or 36-201 or 36-247 or 70-207

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-207 Probability and Statistics for Business Applications**

Fall: 9 units

This is the first half of a year long sequence in basic statistical methods that are used in business and management. Topics include exploratory and descriptive techniques, probability theory, statistical inference in simple settings, basic categorical analysis, and statistical methods for quality control. Not open to students who have received credit for 36-201, 36-220, 36-625, or 36-247. Cross-listed as 70-207.

Prerequisites: 21-112 or 21-121 or 21-120

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-208 Regression Analysis**

Spring: 9 units

This is the second half of a year long sequence in basic statistical methods that are used in business and management. Topics include time series, regression and forecasting. In addition to two lectures a week, students will attend a computer lab once a week. Not open to students who have received credit for 36-202, 36-626. Cross-listed as 70-208. Students who have completed 36-401 prior to 36-208 will not receive credit for 36-208.

Prerequisites: (21-120 or 21-112 or 21-121) and (36-220 or 36-207 or 36-201 or 36-247 or 70-207) and 73-100

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-217 Probability Theory and Random Processes**

All Semesters: 9 units

This course provides an introduction to probability theory. It is designed for students in electrical and computer engineering. Topics include elementary probability theory, conditional probability and independence, random variables, distribution functions, joint and conditional distributions, limit theorems, and an introduction to random processes. Some elementary ideas in spectral analysis and information theory will be given. A grade of C or better is required in order to use this course as a pre-requisite for 36-226 and 36-410. Not open to students who have received credit for 36-225, or 36-625.

Prerequisites: 21-112 or 21-122 or 21-123 or 21-256 or 21-259

Course Website: <http://www.stat.cmu.edu/academics/courselist>

36-220 Engineering Statistics and Quality Control

All Semesters: 9 units

This is a course in introductory statistics for engineers with emphasis on modern product improvement techniques. Besides exploratory data analysis, basic probability, distribution theory and statistical inference, special topics include experimental design, regression, control charts and acceptance sampling. Not open to students who have received credit for 36-201, 36-207/70-207, 36-226, 36-626, or 36-247, except when AP credit is awarded for 36-201.

Prerequisites: 21-112 or 21-121 or 21-120

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-225 Introduction to Probability Theory**

Fall: 9 units

This course is the first half of a year long course which provides an introduction to probability and mathematical statistics for students in economics, mathematics and statistics. The use of probability theory is illustrated with examples drawn from engineering, the sciences, and management. Topics include elementary probability theory, conditional probability and independence, random variables, distribution functions, joint and conditional distributions, law of large numbers, and the central limit theorem. A grade of C or better is required in order to advance to 36-226 and 36-410. Not open to students who have received credit for 36-217 or 36-625.

Corequisites: 21-268 and 21-259 and 21-256

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-226 Introduction to Statistical Inference**

Spring: 9 units

This course is the second half of a year long course in probability and mathematical statistics. Topics include maximum likelihood estimation, confidence intervals, and hypothesis testing. If time permits there will also be a discussion of linear regression and the analysis of variance. A grade of C or better is required in order to advance to 36-401, 36-402 or any 36-46x course. Not open to students who have received credit for 36-626.

Prerequisites: 15-359 or 36-217 or 21-325 or 36-225

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-247 Statistics for Lab Sciences**

Spring: 9 units

This course is a single-semester comprehensive introduction to statistical analysis of data for students in biology and chemistry. Topics include exploratory data analysis, elements of computer programming for statistics, basic concepts of probability, statistical inference, and curve fitting. In addition to two lectures, students attend a computer lab each week. Not open to students who have received credit for 36-201, 36-207/70-207, 36-220, or 36-226.

Prerequisites: 21-121 or 21-112 or 21-120

36-303 Sampling, Survey and Society

Spring: 9 units

This course will revolve around the role of sampling and sample surveys in the context of U.S. society and its institutions. We will examine the evolution of survey taking in the United States in the context of its economic, social and political uses. This will eventually lead to discussions about the accuracy and relevance of survey responses, especially in light of various kinds of nonsampling error. Students will be required to design, implement and analyze a survey sample.

Prerequisites: 36-309 or 36-226 or 36-208 or 36-202 or 36-625 or 70-208 or 73-261 or 88-250

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-309 Experimental Design for Behavioral and Social Sciences**

Fall: 9 units

Statistical aspects of the design and analysis of planned experiments are studied in this course. A clear statement of the experimental factors will be emphasized. The design aspect will concentrate on choice of models, sample size and order of experimentation. The analysis phase will cover data collection and computation, especially analysis of variance and will stress the interpretation of results. In addition to a weekly lecture, students will attend a computer lab once a week.

Prerequisites: 36-220 or 36-217 or 36-207 or 36-201 or 36-247

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-315 Statistical Graphics and Visualization**

Spring: 9 units

Graphical displays of quantitative information take on many forms as they help us understand both data and models. This course will serve to introduce the student to the most common forms of graphical displays and their uses and misuses. Students will learn both how to create these displays and how to understand them. As time permits the course will consider some more advanced graphical methods such as computer-generated animations. Each student will be required to engage in a project using graphical methods to understand data collected from a real scientific or engineering experiment. In addition to two weekly lectures there will be lab sessions where the students learn to use software to aid in the production of appropriate graphical displays.

Prerequisites: 36-202 or 36-208 or 36-226 or 36-303 or 36-309 or 36-625 or 88-250 or 70-208

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-326 Mathematical Statistics (Honors)**

Spring: 9 units

This course is a rigorous introduction to the mathematical theory of statistics. A good working knowledge of calculus and probability theory is required. Topics include maximum likelihood estimation, confidence intervals, hypothesis testing, Bayesian methods, and regression. A grade of C or better is required in order to advance to 36-401, 36-402 or any 36-46x course. Not open to students who have received credit for 36-625.

Prerequisites: 15-359 or 21-325 or 36-217 or 36-225 with a grade of A AND advisor approval.

Prerequisites: 15-359 or 36-217 or 21-325 or 36-225

36-350 Statistical Computing

Fall: 9 units

Statistical Computing: An introduction to computing targeted at statistics majors with minimal programming knowledge. The main topics are core ideas of programming (functions, objects, data structures, flow control, input and output, debugging, logical design and abstraction), illustrated through key statistical topics (exploratory data analysis, basic optimization, linear models, graphics, and simulation). The class will be taught in the R language. No previous programming experience required. Pre-requisites: (36-202, 36-208, or 36-309), plus ("computing at Carnegie Mellon" or consent of instructor) and 36-225 co-requisite.

Prerequisites: 36-202 or 36-208 or 70-208 or 36-309

Corequisite: 36-225

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-401 Modern Regression**

Fall: 9 units

This course is an introduction to the real world of statistics and data analysis. We will explore real data sets, examine various models for the data, assess the validity of their assumptions, and determine which conclusions we can make (if any). Data analysis is a bit of an art; there may be several valid approaches. We will strongly emphasize the importance of critical thinking about the data and the question of interest. Our overall goal is to use a basic set of modeling tools to explore and analyze data and to present the results in a scientific report. A minimum grade of C in any one of the pre-requisites is required. A grade of C is required to move on to 36-402 or any 36-46x course.

Prerequisites: (36-226 or 36-326 or 36-625) and (21-240 or 21-241)

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-402 Advanced Methods for Data Analysis**

Spring: 9 units

This course introduces modern methods of data analysis, building on the theory and application of linear models from 36-401. Topics include nonlinear regression, nonparametric smoothing, density estimation, generalized linear and generalized additive models, simulation and predictive model-checking, cross-validation, bootstrap uncertainty estimation, multivariate methods including factor analysis and mixture models, and graphical models and causal inference. Students will analyze real-world data from a range of fields, coding small programs and writing reports.

Prerequisites: 36-401

Prerequisite: 36-401

Course Website: <http://www.stat.cmu.edu/academics/courselist>

36-410 Introduction to Probability Modeling

Spring: 9 units

An introductory-level course in stochastic processes. Topics typically include Poisson processes, Markov chains, birth and death processes, random walks, recurrent events, and renewal theory. Examples are drawn from reliability theory, queuing theory, inventory theory, and various applications in the social and physical sciences.

Prerequisites: 21-325 or 36-217 or 36-225 or 36-625

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-428 Time Series**

Spring: 6 units

The course is designed for graduate students and advanced undergraduate students. It will introduce the analysis and some of the theory of sequences of serially-dependent random variables (known as time series). Students should already have learned mathematical probability and statistics, including multivariate and conditional distributions, linear regression, calculus, matrix algebra, and the fundamentals of complex variables and functions. The focus will be on popular models for time series and the analysis of data that arise in applications.

Prerequisite: 36-401

36-459 Statistical Models of the Brain

Spring: 12 units

This new course is intended for CNBC students, as an additional option for fulfilling the computational core course requirement, but it will also be open to Statistics and Machine Learning students. It should be of interest to anyone wishing to see the way statistical ideas play out within the brain sciences, and it will provide a series of case studies on the role of stochastic models in scientific investigation. Statistical ideas have been part of neurophysiology and the brain sciences since the first stochastic description of spike trains, and the quantal hypothesis of neurotransmitter release, more than 50 years ago. Many contemporary theories of neural system behavior are built with statistical models. For example, integrate-and-fire neurons are usually assumed to be driven in part by stochastic noise; the role of spike timing involves the distinction between Poisson and non-Poisson neurons; and oscillations are characterized by decomposing variation into frequency-based components. In the visual system, V1 simple cells are often described using linear-nonlinear Poisson models; in the motor system, neural response may involve direction tuning; and CA1 hippocampal receptive field plasticity has been characterized using dynamic place models. It has also been proposed that perceptions, decisions, and actions result from optimal (Bayesian) combination of sensory input with previously-learned regularities; and some investigators report new insights from viewing whole-brain pattern responses as analogous to statistical classifiers. Throughout the field of statistics, models incorporating random "noise" components are used as an effective vehicle for data analysis. In neuroscience, however, the models also help form a conceptual framework for understanding neural function. This course will examine some of the most important methods and claims that have come from applying statistical thinking

Prerequisite: 36-401

36-461 Special Topics: Statistical Methods in Epidemiology

Intermittent: 9 units

TBD

Prerequisite: 36-401

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-462 Special Topics: Data Mining**

Intermittent: 9 units

Data mining is the science of discovering patterns and learning structure in large data sets. Covered topics include information retrieval, clustering, dimension reduction, regression, classification, and decision trees.

Prerequisites: 36-401 (C or better).

Prerequisite: 36-401

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-463 Special Topics: Multilevel and Hierarchical Models**

Intermittent: 9 units

Multilevel and hierarchical models are among the most broadly applied "sophisticated" statistical models, especially in the social and biological sciences. They apply to situations in which the data "cluster" naturally into groups of units that are more related to each other than they are the rest of the data. In the first part of the course we will learn about Bayesian statistical methods. In the second part we will relate multilevel and hierarchical models to other areas of statistics, and in the third part of the course we will build and apply these models using a variety of data sets and examples. Prerequisites: 36-401 (C or better).

Prerequisite: 36-401

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-464 Special Topics: Applied Multivariate Methods**

Intermittent: 9 units

This course is an introduction to applied multivariate methods. Topics include a discussion of the multivariate normal distribution, the multivariate linear model, repeated measures designs and analysis, principle component and factor analysis. Emphasis is on the application and interpretation of these methods in practice. Students will use at least one statistical package.

Prerequisites: 36-401 (C or better).

Prerequisite: 36-401

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-490 Undergraduate Research**

Spring: 9 units

This course is designed to give undergraduate students experience using statistics in real research problems. Small groups of students will be matched with clients and do supervised research for a semester. Students will gain skills in approaching a research problem, critical thinking, statistical analysis, scientific writing, and conveying and defending their results to an audience. Eligible students will receive information about the application processes for this course early in the fall.

Prerequisite: 36-401

Corequisite: 36-402

Course Website: <http://www.stat.cmu.edu/academics/courselist>**36-492 Topic Detection and Document Clustering**

Intermittent: 6 units

Imagine if someone read all your email. Everything you sent, everything you received. What would they find? Do you have repeating topics? How do the topics change over time? The Enron Corporation was an energy, commodities, and services company in Houston, Texas that went spectacularly bankrupt in 2001 after it was revealed that it was engaging in systematic, planned accounting fraud. At its peak, it employed over 20,000 people with revenues over \$100 billion. Its downfall was related to deregulation of California's energy commodity trading and a series of rolling power blackouts over months. For example, Enron traders encouraged the removal of power during the energy crisis by suggesting plant shutdowns. The resulting increase in the price for power made them a fortune. After Enron's collapse, journalists used the Freedom of Information Act to release the emails sent/received by the employees of Enron. Subsequently, the emails were analyzed to see who knew what and when. Every news article, email, letter, blog, tweet, etc can be thought of as an observation. We characterize these documents by their length, what words they use and how often, and possibly extra information like the time, the recipient, etc. Topic detection and document clustering methods are statistical and machine learning tools that extract and identify related documents, possibly over time. These methods need to be flexible enough to handle both very small and very large clusters of documents, topics that change in importance, and topics that appear and disappear. This class will emphasize application of methods and real-world data analysis. Class time will be split into lecture and "lab". (Bring your laptop.) Occasional homeworks and final project, but mostly we'll focus on the downfall of Enron as our overarching case study.

Prerequisite: 36-401

36-494 Astrostatistics

Intermittent: 6 units

Since a young age, many of us have pondered the vastness and beauty of the Universe as we gazed up at the night sky. Planets, moons, stars, galaxies, and beyond have fascinated humanity for centuries. It turns out it also provides a plethora of interesting and complex statistical problems. In this course, problems in astronomy, cosmology, and astrophysics are going provide motivation for learning about some advanced statistical methodology. Possible topics include computational statistics, topological data analysis, nonparametric regression, spatial statistics, and statistical learning. While exploring newer statistical methodology, we will get to sample a variety of problems that appeal to astrostatisticians. Statistical problems related to exoplanets (planets orbiting stars outside our Solar System), the large-scale structure of the Universe (the "Cosmic Web"), dark matter (over 80% of the matter in the Universe is thought to be invisible), Type Ia supernova (a dying star eats its companion star until explodes), cosmic microwave background (a.k.a. "baby pictures of the Universe") are some possibilities. This course will be suitable for advanced undergraduate statistics majors through Ph.D. level statistics students, and astronomy Ph.D. students with some background in statistics.

Prerequisite: 36-401

36-625 Probability and Mathematical Statistics I

Fall: 12 units

This course is a rigorous introduction to the mathematical theory of probability, and it provides the necessary background for the study of mathematical statistics and probability modeling. A good working knowledge of calculus is required. Topics include combinatorial analysis, conditional probability, generating functions, sampling distributions, law of large numbers, and the central limit theorem. Undergraduate students studying Computer Science, or considering graduate work in Statistics or Operations Research, must receive permission from their advisor and from the instructor. Prerequisite: 21-122 and 21-241 and (21-256 or 21-259). Prerequisites: 21-118 or 21-122 or 21-256 or 21-123

36-626 Probability and Mathematical Statistics II

Intermittent: 12 units

An introduction to the mathematical theory of statistical inference. Topics include likelihood functions, estimation, confidence intervals, hypothesis testing, Bayesian inference, regression, and the analysis of variance. Not open to students who have received credit for 36-226. Students studying Computer Science should carefully consider taking this course instead of 36-220 or 36-226 after consultation with their advisor. Prerequisite: 36-625. Prerequisite: 36-625

36-692 Topic Detection and Document Clustering

Intermittent: 6 units

Imagine if someone read all your email. Everything you sent, everything you received. What would they find? Do you have repeating topics? How do the topics change over time? The Enron Corporation was an energy, commodities, and services company in Houston, Texas that went spectacularly bankrupt in 2001 after it was revealed that it was engaging in systematic, planned accounting fraud. At its peak, it employed over 20,000 people with revenues over \$100 billion. Its downfall was related to deregulation of California's energy commodity trading and a series of rolling power blackouts over months. For example, Enron traders encouraged the removal of power during the energy crisis by suggesting plant shutdowns. The resulting increase in the price for power made them a fortune. After Enron's collapse, journalists used the Freedom of Information Act to release the emails sent/received by the employees of Enron. Subsequently, the emails were analyzed to see who knew what and when. Every news article, email, letter, blog, tweet, etc can be thought of as an observation. We characterize these documents by their length, what words they use and how often, and possibly extra information like the time, the recipient, etc. Topic detection and document clustering methods are statistical and machine learning tools that extract and identify related documents, possibly over time. These methods need to be flexible enough to handle both very small and very large clusters of documents, topics that change in importance, and topics that appear and disappear. This class will emphasize application of methods and real-world data analysis. Class time will be split into lecture and "lab". (Bring your laptop.) Occasional homeworks and final project, but mostly we'll focus on the downfall of Enron as our overarching case study.

36-700 Probability and Mathematical Statistics I

Fall: 12 units

to be determined by department

36-705 Intermediate Statistics

Fall: 12 units

This course covers the fundamentals of theoretical statistics. Topics include: probability inequalities, point and interval estimation, minimax theory, hypothesis testing, data reduction, convergence concepts, Bayesian inference, nonparametric statistics, bootstrap resampling, VC dimension, prediction and model selection.

36-746 Statistical Methods for Neuroscience and Psychology

Intermittent: 12 units

This course provides a survey of basic statistical methods, emphasizing motivation from underlying principles and interpretation in the context of neuroscience and psychology. Though 36-746 assumes only passing familiarity with school-level statistics, it moves faster than typical university-level first courses. Vectors and matrices will be used frequently, as will basic calculus. Topics include Probability, Random Variables, and Important Distributions (binomial, Poisson, and normal distributions; the Law of Large Numbers and the Central Limit Theorem); Estimation and Uncertainty (standard errors and confidence intervals; the bootstrap); Principles of Estimation (mean squared error; maximum likelihood); Models, Hypotheses, and Statistical Significance (goodness-of-fit, p-values; power); General methods for testing hypotheses (permutation, bootstrap, and likelihood ratio tests); Linear Regression (simple linear regression and multiple linear regression); Analysis of Variance (one-way and two-way designs; multiple comparisons); Generalized Linear and Nonlinear Regression (logistic and Poisson regression; generalized linear models); and Nonparametric regression (smoothing scatterplots; smoothing histograms).

36-762 Data Privacy

Fall: 6 units

Protection of individual data is a growing problem due to the large amount of sensitive and personal data being collected, stored, analyzed, and shared across multiple domains and stakeholders. Researchers are facing new policies and technical requirements imposed by funding agencies on accessing and sharing of the research data. This course will introduce students to (1) key principles associated with the concepts of confidentiality and privacy protection, and (2) techniques for data sharing that support useful statistical inference while minimizing the disclosure of sensitive personal information. Methodologies to be considered will include tools for disclosure limitation used by government statistical agencies and those associated with the approach known as differential privacy which provides a formal privacy guarantee. Students will explore specific techniques using special tools in R.

36-792 Topic Detection and Document Clustering

Intermittent: 6 units

Imagine if someone read all your email. Everything you sent, everything you received. What would they find? Do you have repeating topics? How do the topics change over time? The Enron Corporation was an energy, commodities, and services company in Houston, Texas that went spectacularly bankrupt in 2001 after it was revealed that it was engaging in systematic, planned accounting fraud. At its peak, it employed over 20,000 people with revenues over \$100 billion. Its downfall was related to deregulation of California's energy commodity trading and a series of rolling power blackouts over months. For example, Enron traders encouraged the removal of power during the energy crisis by suggesting plant shutdowns. The resulting increase in the price for power made them a fortune. After Enron's collapse, journalists used the Freedom of Information Act to release the emails sent/received by the employees of Enron. Subsequently, the emails were analyzed to see who knew what and when. Every news article, email, letter, blog, tweet, etc can be thought of as an observation. We characterize these documents by their length, what words they use and how often, and possibly extra information like the time, the recipient, etc. Topic detection and document clustering methods are statistical and machine learning tools that extract and identify related documents, possibly over time. These methods need to be flexible enough to handle both very small and very large clusters of documents, topics that change in importance, and topics that appear and disappear. This class will emphasize application of methods and real-world data analysis. Class time will be split into lecture and "lab". (Bring your laptop.) Occasional homeworks and final project, but mostly we'll focus on the downfall of Enron as our overarching case study.

StuCo (Student Led Courses) Courses**98-251 Student Taught Courses (StuCo): Racecar Engineering**

Fall and Spring: 3 units

This course aims to teach students about the systems contained on a racing vehicle, along with the practical design and manufacturing theory behind it. Topics include system overviews, modern manufacturing processes, design intuition, computer simulation tools and modelling. A heavy focus will be placed on hands-on activity and learning relevant knowledge to the engineering discipline. No previous knowledge is necessary, and all majors are welcome.

98-252 Student Taught Courses (StuCo): Wordplay: Fundamentals of Scrabble Strategy

Fall and Spring: 3 units

Contrary to popular belief, knowledge of obscure words is not the foremost determiner of Scrabble success. This course will cover the strategies and paradigms that advanced players employ to consistently outplay even those with wider vocabularies, including: anagramming; bingos; rack management; S, blank, and Q strategy; defense; bluffing and challenging; exchanging; and endgame finesse. Beginning with the rules of Scrabble, the course does not presume any prior experience and is absolutely accessible to beginners. Classes will follow a structure of alternating lessons and workshops where students will have the opportunity to practice skills with each other in real Scrabble games. Course Site: <http://www.contrib.andrew.cmu.edu/~jemminc/98-252/>

98-253 Student Taught Courses (StuCo): Beginner Throwing: An Introduction to Yo-yo

Fall and Spring: 3 units

Modern yo-yo is an exciting hobby and an interesting combination of art and sport requiring both creativity and dexterity. This course will be an introduction to 1A style yo-yo (single yo-yo, string tricks) that will start with basic techniques and lead into a variety of types of tricks. Responsive play will be introduced at first, followed by unresponsive play in order to perform more advanced tricks. Class will consist of practicing tricks presented through videos and demonstrations. As a final, students will create a unique trick to be presented to the class along with a short tutorial video explaining and teaching the trick.

98-254 Student Taught Courses (StuCo): Ukulele For Non-Majors

Fall and Spring: 3 units

The ukulele is one of the most accessible instruments created; unlike the guitar or piano, the ukulele only has four strings and is much smaller, which is easier to transport. This makes it an ideal instrument for making music anywhere. This course will develop the musical abilities of students through a combined crash course of basic harmony, eurhythmic, and solfege, while simultaneously applying that knowledge to the ukulele. Students will acquire knowledge in music theory to order to read and build chords, a skill important to learning songs. Students will also acquire a rhythmic ability such that they can strum comfortably and effortlessly. Lastly, students will acquire some form of vocal and ear knowledge to assist in their education. The course may be intensive for students with absolutely no musical ability. Students will learn a variety of techniques in weekly classes and the broad scope of musical development may prove a little difficult. However, this can be amended with adequate practice, which is emphasized at the end of each class. Students are required to purchase their own ukulele instruments. Prices range from \$30-\$45.

98-255 Student Taught Courses (StuCo): Cosplay 101

Fall and Spring: 3 units

This course will provide a foundation for obtaining the skills and mindset required for creating a cosplay out?t. Students will learn essential techniques such as using a sewing machine, determining materials, working with ?found objects? to create props and costumes, and other basic cosplay knowledge. By the end of the course students will be able to employ the knowledge learned in class to create a cosplay of their choosing!

98-256 Student Taught Courses (StuCo): Introduction to Humor Theory, for Non-Majors

Fall and Spring: 3 units

This course focuses on the underlying principles of humor. We will ask questions such as, "Why is this joke funny??" "Under what circumstances is this joke funny?", and "What would make this joke funnier?" By asking these questions in context of various genres, styles, and settings, we hope to illuminate some of the underlying principles that make a joke ? work. ? Some recurring themes will be: the intended effect of humor on the audience, the structural elements of jokes, and the relationship between a joke and its medium. The course will be discussion-based, since humor is both subjective and an inherently social subject. Topics include: puns, anti-humor, stand-up comedy, one-liners, meta humor, and literary humor. There is no course fee.

98-257 Student Taught Courses (StuCo): Women in Film

Fall and Spring: 3 units

This course will explore the role of women in film and how the medium treats female characters and their stories. We will look at films with prominent female characters as well as films that have been written or directed by women.

98-258 Student Taught Courses (StuCo): Pokemon 101

Fall and Spring: 3 units

Course In 1996 Pokémon Red and Green/Blue were released and would soon gain rapid popularity and become not only the best selling RPG on the original Game Boy but become one of the best selling RPG of all time. This led to future sequels and becoming the multi-billion dollar franchise known today. Amongst many of the groundbreaking features the series started and evolved over time the biggest is often referred to its battle system. It spawned a competitive environment based on the system's heavy need of predication and preparation analysis for high level play and has continued to evolve with each passing sequel. In this course we will introduce the depth of the battle mechanics and move into developing and analyzing strategies. The course will consist of lectures and discussions on the mechanics, strategy, meta, and team composition along with a few progress reports and a tournament amongst the class for the final.

98-259 Student Taught Courses (StuCo): General Tso's Chicken: A Detour to Chinese Langu

Fall and Spring: 3 units

Many of you are familiar with General Tso's chicken, Kung Pao chicken, Ma Po Tofu, dumplings, and spring rolls. However, few of you can answer the following questions: Who is General Tso? What is Kung Pao? Where is Ma Po from? Who invented dumplings? Why do we eat spring rolls? If you are curious about the answers, you will get them, in English, from this course. Through Chinese food, this course provides an interesting explanation of obscure aspects of Chinese language and culture. Each lecture has a culture session and a language session. In the culture session, you will be introduced several Chinese dishes and relevant stories or legends, leading us to specific Chinese words, customs or philosophies. We will then compare and contrast them with your own language and culture to achieve a better understanding. In the language session, you will take away some sophisticated yet practical Chinese phrases (or even verses from a poem) related to the food. Get ready to impress your Chinese friends, colleagues, or business associates.

98-260 Student Taught Courses (StuCo): Mindfulness-Based Stress Reduction

Fall and Spring: 3 units

Mindfulness-Based Stress Reduction (MBSR) was originally developed at UMass Medical Center. MBSR brings together mindfulness and conscious breathing with yoga and meditation in order to increase attention span and reduce stress naturally. With the exception of the introduction in the 1st week, the midterm in the 8th week, and the final in the 16th week, every class will consist of 25 minutes of ?class time? - in-class worksheets, activities, group discussion, etc.; the remaining 25 minutes will be used for meditation and yoga purposes. Remember to wear comfortable clothing to class, as 25 minutes every week will consist of a guided meditation! Feel free to bring a yoga mat to lie on if you so choose, though it is not required.

98-261 Student Taught Courses (StuCo): The Captivity Debate: Killer Whales

Fall and Spring: 3 units

The death of experienced SeaWorld trainer Dawn Brancheau in February of 2010 raised questions about humans? relationship with killer whales and the suitability of keeping them in captivity for human entertainment. This course will explore the history of killer whales in captivity, delve into the behavior of killer whales in the wild, compare it to that of killer whales in captivity, and question humans? role in the lives of highly intelligent, emotionally complex creatures.

98-262 Student Taught Courses (StuCo): Intro to Boardgames and Miniature Wargames

Fall and Spring: 3 units

This course will introduce students to the hobby of boardgames, nonstandard cardgames and miniature wargames. We will be playing a wide variety of game genres and investigating their mechanics, with the ultimate goal of expanding your knowledge of the wide varieties of games and understanding their mechanics enough to extend similar principles of play to games that use similar mechanics. What Kinds of Games will we be playing*: ?Eurogames?: Settlers of Catan, Carcassonne, Ticket to Ride, Stone Age, Puerto Rico, etc. Nonstandard Card Games: Fluxx, Pit, Race for the Galaxy, The Resistance, etc. Miniature Wargames (The games we will play are similar to): Warhammer (Fantasy/40K), Flames of War, Bolt-Action, Dystopian Wars, etc. Board wargames: Diplomacy, Axis and Allies, Battle Cry, etc. What Kinds of Games we will NOT be playing (Including but not limited to the following examples): Common household boardgames: Risk, Monopoly, Dominoes, Sorry, Apples to Apples, Scrabble, Clue, Life, Trivial Pursuit, etc. Standard 52 Card Deck Card Games: Blackjack, Poker, Rummy, etc. Traditional Games: Chess, Checkers, Go, Nine Man's Morris, etc.

98-264 Student Taught Courses (StuCo): Brick Walls and First Bases: A History of Comedy

Fall and Spring: 3 units

So, why am I here, exactly? E.B. White once said, "Analyzing a joke is like dissecting a frog. Few people are interested and the frog dies."* Brick Walls and First Bases is a course dedicated to hitting that balance between knowing why jokes are funny and knowing so much about jokes that they just aren't funny anymore.** We will be covering general historical trends in comedy as well as discussing comedic theory and social aspects vital to what makes something funny. The goal of this course is to know how comedy developed into what it is today. There will also be a notable focus on the contemporary comedy scene in America. Ok, I get it, comedy's great. How will I learn about how great it is? This class will meet once a week from 6:30p.m. to 7:30p.m. During this time there will either be lecture or discussion. There will also be short, weekly homework assignments posted by me on blackboard. It is your responsibility to come to class having listened to or watched the necessary reading or video, so you can participate in class. There will also be a midterm exam and a final (students can choose either a paper or presentation) to show what you learned throughout the class. (Just think of how cool you'll seem to your friends when you told them you were once ostensibly forced by someone who is barely your superior to write a paper on Mort Sahl! How exciting.)

98-265 Student Taught Courses (StuCo): Hello Theater: The Logic of Illogical Methods

Fall and Spring: 3 units

This course explores how to a) Understand Various Theatrical techniques (both modern and traditional) b) Increasing Appreciation for Non-traditional theater and examining its strengths and merits c) Practical techniques for improving your own theatrical work. The course also explores closely related areas like leadership, learning theory, psychology and post-modernist culture.

98-267 Student Taught Courses (StuCo): Jamaican Entertainment

Spring: 3 units

This course is meant to examine the entertainment industry in Jamaica. The first-half of the semester will first examine the cultural aspects of the industry, such as the origins and types of: dance, food, music, and dialect. Given this background, the second-half of the semester will dive into event planning and management in the context of this culture; such as marketing, budgeting and finances.

98-268 Student Taught Courses (StuCo): The Scary Story: Gothic Lit and the Uncanny

Spring: 3 units

This course on Gothic literature and the scary story is for anyone who is intrigued by things that chill the blood and tingle the spine. All are welcome, from literary enthusiasts to those who haven't taken an English course in years; all you need is an interest in storytelling and curiosity about human darkness. The course will explore Gothic themes, the nature of the uncanny, and the evolution of the scary story across region and time. How is the scary story colored by history and folklore? What psychological horrors lurk at the core of all truly scary stories? How does the history of the scary story relate to contemporary horror media? We will explore these questions and many more through authors such as Edgar Allan Poe, H. P. Lovecraft, Joyce Carol Oates, and a host of others. Class will be primarily lecture- and discussion-based. The midterm and final will allow you to create your own scary stories or creations to be shared in a spooky campfire- esque setting. Enroll if you dare!

98-269 Student Taught Courses (StuCo): Intro to Sabermetrics & Exploring Baseball Data

Spring: 3 units

Born in the 1970s and popularized by ?

Moneyball? as a radical challenge to traditional

baseball statistics, sabermetrics has developed into a new way of understanding Ame

s

pastime. Its practitioners have created new statistical tools and revised our old ways

thinking about the game, transforming the way fans and front offices view and assess

the game.

This introduction to the basics of sabermetrics will explain concepts including normal

distribution

calculations like OPS (On-

base plus Slugging), WHIP (Walks and Hits per Inning Pitched), PF

(Park Factor) and others increasingly used by members of the sabermetrics communit

ies.

98-270 Student Taught Courses (StuCo): Quadrotors: Robots in da Skies

Spring: 3 units

"Drones". "UAV's". We are starting to hear these words in the media, often in a negativ

But there is a world of hobbyists that play with the same machines with an entirely differe

"Quadrotors" (robots that are like helicopters, but with four motors and blades) are being

beautiful footage from unique perspectives (http://www.youtube.com/watch?v=J2Hui_fUOBA), to lift beer (<http://www.youtube.com/watch?v=qmHwXf8JU0w>), for research (<http://www.youtube.com/watch?v=w2itwFJCGFQ>) and even for music (http://www.youtube.com/watch?v=_sUeGC8dyk), and they are a blast to build, tinker with, and fly.

We hope to use these robots as an introduction to the world of hobbyists for any student

interested in robotics.

"something that they can fly" fun. It is not hard to learn to build a quadrotor, it is just a

bit more challenging than building a plane or a boat.

taught. We would love for students in fields such as "fine arts" or "business" to take this

course. We have designed it to be understood by a non-

technical audience, but to be enjoyed by everyone. Take our

StuCo and harass your roommate by flying at them with your very own quadrotor that Y

98-271 Student Taught Courses (StuCo): Speedrunning 101%

Spring: 3 units

This course focuses on teaching students the principles of Speedrunning, including

choosing games, learning games, designing splits, recording/

streaming their runs, and racing.

We will cover everything from the basics and lingo, to the software used for recording, a

nd how to integrate into the speedrunning community.

98-272 Student Taught Courses (StuCo): Financial Freedom

Spring: 3 units

Financial freedom is the moment when you no longer work for money, but rather, when you let your money work for you. When you choose to work because you love your job over the necessity of working for a salary, you become financially independent. This is a course about personal finance and investing. We will cover topics from credit to getting started with your own 5-minute-a-month investment portfolio. We will also hold several workshops and one-on-ones on topics like applying for a credit card, paying off student loans, and filing taxes. Empower yourself to make important decisions in your life by learning about the steps to achieve your financial freedom.

98-273 Student Taught Courses (StuCo): Mermaidology

Spring: 3 units

This course will focus on mermaids: what they are, where the stories and myths arose from, and how they affect us today. Topics including the origin of mermaids, mermaids in mythology, gender and sexuality in mermaids, mermaids in the media, and the existence of mermaids will be covered in this StuCo. We will use stories such as Hans Christian Andersen's "The Little Mermaid", movies such as Disney's The Little Mermaid and Peter Pan, and even cultural icons like Aquaman to get a better understanding of the mermaid phenomenon and how it affects us.

98-274 Student Taught Courses (StuCo): How to Start an Anonymous Website

Spring: 3 units

Whatever you do on the Internet, everything starts with your IP address.

On the conventional Internet, routing protocols ensure that nothing you do

can be... (finishing this later...some statement will be made here about

the motivation/concerns for online anonymity and privacy, and its personal

and political implications...) The Tor project originated a few years ago as

a result of the combination of the development and implementation of new

encryption technologies and increasing concerns for privacy.

98-275 Student Taught Courses (StuCo): Marvel Film and Media Studies

Intermittent: 3 units

This course is an exploration of one of the last decade's most successful media franchises: the Marvel Cinematic Universe (MCU), which began with 2008's "Iron Man," continuing with titles such as "The Avengers" and "Guardians of the Galaxy." Each class session will focus on a specific film (or television shows) in the MCU. We will study each film from both a filmmaking standpoint and a thematic standpoint; we will begin by following the production of each film before delving into the story and content. We will also examine the cultural influence and impact of the MCU entries; topics will range from Wikileaks to Tumblr fandom. This course is for students who desire to learn more about the behind-the-scenes process behind some of their favorite films, or to just talk about how much they love Groot.

98-276 Student Taught Courses (StuCo): Learning the Ropes

Intermittent: 3 units

Jump rope has risen from a playground activity to an internationally competitive sport. This StuCo will expose students to the basics of jump rope as a little-known sport and have them develop creativity and skills throughout the semester. Students will perform a choreographed routine at Dancers Symposium as a final project and will also have created a simple "freestyle" using the skills that they have learned. There is a course fee of \$6 for a jump rope. The course fee is due to the instructor in person on the first day of class.

98-277 Student Taught Courses (StuCo): Vim Editor: Philosophy, Principles and Practice

Intermittent: 3 units

Vim is a very powerful text editor that is often misused. This is because Vim has an editing model that is fundamentally different from almost all other editors out there, and it takes quite a bit of understanding to truly edit text at the speed of thought. The main purpose of this course is to answer the question: Why Vim? We will trace the roots of the Vim editor, and explain in detail how to think in Vim, how to utilize the most out of its commands, and how people use it in practice. We will also be talking a bit about some of the traps that beginners fall into, and will intentionally avoid topics that are too misleading. This course is mostly geared towards CS/ECE majors who spend most of their time coding in a C-style language.

Tepper School of Business Courses

45-816 Studies in Financial Engineering

Fall: 6 units

This course is about using financial engineering and derivative securities to solve practical business problems. Students will work through business cases and give in-class simulated sales pitches to hypothetical clients. The cases highlight the design, valuation and hedging of structured products on stock prices, interest rates, FX, and exotic "underlyings" such as volatility, credit, and energy. Reference text: Hull, J., Option, Futures and Other Derivative Securities, 2nd edition, Prentice-Hall, 1993

45-925 Studies in Financial Engineering

Fall: 6 units

This course is about using financial engineering and derivative securities to solve practical business problems. Students will work through business cases and give in-class simulated sales pitches to hypothetical clients. The cases highlight the design, valuation and hedging of structured products on stock prices, interest rates, FX, and exotic "underlyings" such as volatility, credit, and energy. Reference text: Hull, J., Option, Futures and Other Derivative Securities, 2nd edition, Prentice-Hall, 1993.

Tepper School of Business Courses

46-971 Presentations for Computational Finance

Fall: 6 units

to be determined

46-972 MSCF Finance

Fall: 6 units

To be determined

46-973 MSCF Options

Fall: 6 units

to be determined

46-976 Financial Optimization

Fall: 6 units

to be determined

46-978 Financial Economics for Comp Finance

Fall: 6 units

to be determined

Tepper School of Business Courses

47-711 Issues in Taxation for Accounting & Finance

Intermittent: 6 units

This course will cover research in accounting, finance and economics related to business taxation. The focus will be empirical although some theoretical models will be discussed in order to address optimal tax policies in different contexts. Potential topics include international taxation and the effects of tax havens, measuring and explaining the cross-sectional pattern of corporate tax avoidance, issues in accounting for income taxes, and the taxation of executive compensation.

47-739 Topics in Consumer Behavior

Intermittent: 6 units

to be added later.

47-756 Empirical Models in Marketing

Intermittent: 6 units

To be added later.

47-766 Energy Operations

Intermittent: 6 units

to be added at a later time.

47-991 Communication Skills for the Academic Job Market

Intermittent: 6 units

The academic job market presents a unique set of communication challenges. Some of these include: -briefly and concisely communicating your research -framing your research for those outside your subfield -pitching yourself as a colleague and educator -describing your intended research trajectory -highlighting key concepts and ideas -demonstrating confidence and poise under duress In this course, we'll unpack the complexities of communicating with people you may not know well (i.e., potential employers) and prepare you for these challenges. The goal of the course is to ensure that you can successfully represent yourself as a researcher, educator, and colleague ? from initial contact (including conference presentations) throughout the interviewing and hiring process. This course includes opportunities to practice and strengthen both written and oral skills. It is appropriate for any PhD candidate preparing to enter the academic job market.