COURSE DESCRIPTIONS

SECTION 3

Courses Qualifying for Engineering Distribution Areas ........... 110
Course Descriptions ...................................... 110
Air Force Aerospace Studies ................................ 111
Basic Sciences ........................................... 112
Bioinformatics and Computational Biology .................... 112
Biology and Biotechnology ................................ 113
Biomedical Engineering ................................... 116
Business, School of ....................................... 118
Chemical Engineering ..................................... 123
Chemistry and Biochemistry ................................ 125
Civil and Environmental Engineering ......................... 127
Computer Science ....................................... 130
Electrical and Computer Engineering .......................... 133
Engineering Science Interdisciplinary ......................... 136
Fire Protection Engineering ................................. 138
Humanities and Arts ...................................... 139
Interactive Media and Game Development ........................ 152
Interdisciplinary ......................................... 154
Mathematical Sciences .................................... 155
Mechanical Engineering ................................... 159
Military Science .......................................... 163
Physical Education ....................................... 165
Physics .................................................... 166
Robotics Engineering ...................................... 168
Social Science and Policy Studies .............................. 169
Mathematics
All Courses designated “MA.”
Advanced placement established by AP exam or through passing WPI advanced courses (see page 209) also qualify.

Basic Science
All courses designated “PH,” “CH,” “BB,” and GE 2341.

Engineering Science/Design
The following courses may be applied to the “Engineering Science and Design” distribution requirement for each respective engineering major:

BME: All courses designated “BME” (except BME 3110) and CE, CHE, ECE, RBE, and ME courses at the 2000-level or above.
CE: All courses designated “CE”. Also ES 2503 and ES 3004.
CHE: All courses designated “CHE.” Also ES 3002, ES 3003, ES 3004, and other courses approved by the Chemical Engineering Department. See the department web site, and consult with your academic advisor for details.
ECE: All courses designated “ECE” (except ECE 3601) and ES 3011 may be included in the six-unit ECE area distribution requirement.

RBE: All courses designated “RBE”.
ME: All courses designated “ME”.
IE: OIE courses including BUS 2080, BUS 3020, OIE 3401, OIE 3405, OIE 3420, OIE 3460, OIE 3501, OIE 4410, and OIE 4460.
In addition, engineering majors selecting “Engineering Science/Design” courses from outside their major may choose appropriate activities from any of the following:
All courses designated ES, ECE, CHE, ME, RBE.
All OIE courses listed above (for ME majors only).
All courses designated as CE except CE 3022.
All courses designated as CS except CS 1101, CS 1102, and CS 3043. (Only RBE majors may select CS 1101 or CS 1102 to satisfy the Engineering Science and Design Distribution Requirement. (Electrical and Computer Engineering majors are restricted to these courses at the 2000-level or higher.)
All ABET engineering programs require six units of Engineering Science and Design.
All graduate-level courses may be counted in the appropriate categories.

COURSE DESCRIPTIONS

COURSE CATEGORIES
for purposes of planning programs of study, courses at WPI are divided into two categories.

Category I (Cat. I)
These courses cover core material of interest to large numbers of students. Category I courses are offered at least once a year.

Category II (Cat. II)
Category II courses are usually offered every other year.

BACKGROUND
Recommended
The course will build on material in the recommended course. Instructors can assume that the student is knowledgeable of the material from the recommended course or from other experiences.

Suggested
The material from this course would be helpful to the student, but it is not assumed background.

CATALOG AND SCHEDULE ON THE WWW
The catalog and course schedule can be found on the world wide web at www.wpi.edu/+ugradcat and www.wpi.edu/+schedules.

COURSE NUMBERING
Each course at WPI is designated by a two-letter prefix identifying the subject area followed by a four digit number. The first digit is coded as follows:

1 — Courses for which first-year students will receive priority in registration. Upper class students may register on a space-available basis.

2 — Basic level courses.

3 — Advanced level undergraduate courses for which no graduate credit is given. (This restriction may be waived at the discretion of the degree department.)

4 — Advanced level undergraduate courses for which graduate credit may also be given.

5 — Graduate courses.

The last three digits may be used by the departments to indicate subject areas. Many graduate courses are also available to undergraduates.

COURSE CREDIT
Unless otherwise indicated, WPI courses usually carry credit of 1/3 unit. This level of activity suggests at least 17 hours of work per week, including work outside the classroom, as well as scheduled class and laboratory time. The usual workload per term is 1 unit.
AIR FORCE AEROSPACE STUDIES COURSES

AS 1001. THE FOUNDATIONS OF THE UNITED STATES AIR FORCE I.
Cat. I (1/9 unit)
The AS 1000 sequence of courses are designed to introduce students to the United State Air Force and Air Force Reserve Officer Training Corps. Featured topics include mission and organization of the Air Force, officerhip and professionalism, Air Force officer opportunities, military customs and courtesies, and an introduction to communication skills.

The first course focuses on the foundation of officerhip and customs and courtesies.

The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 1001 Leadership Laboratory includes a study of Air Force customs and courtesies, drill and ceremonies, and military commands.

AS 1002. THE FOUNDATIONS OF THE UNITED STATES AIR FORCE II.
Cat. I (1/9 unit)
The AS 1000 sequence of courses are designed to introduce students to the United State Air Force and Air Force Reserve Officer Training Corps.

A continuation of AS 1001, the course in this series emphasizes those communication skills needed in today's Air Force. It describes the communication systems, discusses common barriers and enhancements to effective communications. The course includes numerous speaking and written exercises using current Air Force topics.

The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 1002 Leadership Laboratory includes a study of Air Force customs and courtesies, drill and ceremonies, and military commands.

AS 1003. THE FOUNDATIONS OF THE UNITED STATES AIR FORCE III.
Cat. I (1/9 unit)
The AS 1000 sequence of courses are designed to introduce students to the United State Air Force and Air Force Reserve Officer Training Corps.

A continuation of AS 1002, the course outlines the origin of the Air Force and the organizational structure of the Air Force with a focus on the missions of select military organizations. The basic history of the United States military is studied in order to appreciate how military history impacts the Air Force today. Written and oral communication skills are practiced.

The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 1003 Leadership Laboratory includes a study of Air Force customs and courtesies, drill and ceremonies, and military commands.

AS 1004. THE FOUNDATIONS OF THE UNITED STATES AIR FORCE IV.
Cat. I (1/9 unit)
The AS 1000 sequence of courses are designed to introduce students to the United State Air Force and Air Force Reserve Officer Training Corps.

The final course in the AS 1000 sequence, it introduces students to the Air Force installation and her sister services. Written and oral communication skills are practiced.

The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 1004 Leadership Laboratory includes a study of Air Force customs and courtesies, drill and ceremonies, and military commands.

Cat. I (1/9 unit)
The AS 2000 sequence of courses are designed to examine general aspects of air and space power through a historical perspective. The course covers a time period from the first balloons and dirigibles to the space-age and space power through a historical perspective. The study of Air Force customs and courtesies, drill and ceremonies, military commands, and preparation for field training.

AS 2002. THE EVOLUTION OF USAF AIR AND SPACE POWER II.
Cat. I (1/9 unit)
The AS 2000 sequence of courses are designed to examine general aspects of air and space power through a historical perspective. The second course in the series continues with the development of air power from World War II through the development of the Intercontinental Ballistic Missile.

The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 2002 Leadership Laboratory continues a study of Air Force customs and courtesies, drill and ceremonies, military commands, and preparation for field training.

AS 2003. THE EVOLUTION OF USAF AIR AND SPACE POWER III.
Cat. I (1/9 unit)
The AS 2000 sequence of courses are designed to examine general aspects of air and space power through a historical perspective. The third course in the series begins with a study of air power in the Vietnam war through the Gulf war. Oral and written communications skills will be practiced.

The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 2003 Leadership Laboratory continues a study of Air Force customs and courtesies, drill and ceremonies, military commands, and preparation for field training.

AS 2004. THE EVOLUTION OF USAF AIR AND SPACE POWER IV.
Cat. I (1/9 unit)
The AS 2000 sequence of courses are designed to examine general aspects of air and space power through a historical perspective. 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 students 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. The final course in the series explores the future of the Air Force through 2025.

The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 2004 Leadership Laboratory continues a study of Air Force customs and courtesies, drill and ceremonies, military commands, and preparation for field training.

AS 3001. AIR FORCE LEADERSHIP STUDIES I.
Cat. I (1/6 unit)
The AS 3000 sequence of courses is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and communication skills required of an Air Force officer. Throughout the courses, case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of concepts being studied.

The first course explores different styles of leadership, followership, and management functions.

The course includes three hours of class work and three hours of mandatory leadership laboratory per week. The AS 3001 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-type activities and giving students the opportunity to apply leadership and management principles.

AS 3002. AIR FORCE LEADERSHIP STUDIES II.
Cat. I (1/6 unit)
The AS 3000 sequence of courses is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and communication skills required of an Air Force officer. The second course studies various aspects of leadership, conflict management, counseling, and supervision.

The course includes three hours of class work and three hours of mandatory leadership laboratory per week. The AS 3002 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-type activities and giving students the opportunity to apply leadership and management principles.

AS 3003. AIR FORCE LEADERSHIP STUDIES III.
Cat. I (1/6 unit)
The AS 3000 sequence of courses is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and communication skills required of an Air Force officer. The third course emphasizes teamwork, improvement process, and military ethics.
The course includes three hours of class work and three hours of mandatory leadership laboratory per week. The AS 3003 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-type activities and giving students the opportunity to apply leadership and management principles.

AS 3004. AIR FORCE LEADERSHIP STUDIES IV. Cat. I (1.6 unit)
The AS 3000 sequence of courses is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and communication skills required of an Air Force junior officer. The final course explores officer professional development, and personnel and evaluation systems including practical exercises.
The course includes three hours of class work and three hours of mandatory leadership laboratory per week. The AS 3004 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-type activities and giving students the opportunity to apply leadership and management principles.

AS 4101. NATIONAL SECURITY AFFAIRS I. Cat. I (1.6 unit)
The AS 4000 sequence of courses examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus the military as a profession, officership, military justice, civilian control of the military, preparation for active duty and current issues affecting military professionalism. Throughout the AS 4000 course of courses, briefings and writing exercises will be accomplished with emphasis on refining communication skills.
The first course examines in depth the national security process, principles of war and the Air Force major commands. The course includes three hours of class work and three hours of mandatory leadership laboratory each week. The AS 4101 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

AS 4102. NATIONAL SECURITY AFFAIRS II. Cat. I (1.6 unit)
The AS 4000 sequence of courses examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. The second course provides a detailed examination of Air Force doctrine including a study of the joint doctrine and the roles of the other military services. The course includes three hours of class work and three hours of mandatory leadership laboratory each week. The AS 4102 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

AS 4103. NATIONAL SECURITY AFFAIRS III. Cat. I (1.6 unit)
The AS 4000 sequence of courses examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. The third course provides an extensive study of alliances and regional security issues, including international peacekeeping and terrorism. Continued attention is given to developing the research and communications skills required by junior officers.
The course includes three hours of class work and three hours of mandatory leadership laboratory each week. The AS 4103 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

AS 4104. PREPARATION FOR ACTIVE DUTY. Cat. I (1.6 unit)
The AS 4000 sequence of courses examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. The final course in the series examines officership, the military justice system, social responsibilities, current issues affecting the military profession, and various factors that will facilitate a smooth transition from civilian to military life.
The course includes three hours of class work and three hours of mandatory leadership laboratory each week. The AS 4104 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

BASIC SCIENCES

GEOSCIENCES (GE)

GE 2341. GEOLOGY. Cat. I
Students of this course will examine the fundamental principles of physical geology including the materials, structures, and surface features of the earth and the processes which produced them. Emphasis will be placed on the interrelations of people and environment and applications to various fields of technology. The course includes field trips and a significant laboratory component.

BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

BCB 4001. BIOINFORMATICS. Cat. II
This course will provide an overview of bioinformatics, covering a broad selection of the most important techniques used to analyze biological sequence and expression data. Students will acquire a working knowledge of bioinformatics applications through hands-on use of software to ask and answer biological questions. In addition, the course will provide students with an introduction to the theory behind some of the most important algorithms used to analyze sequence data (for example, alignment algorithms and the use of hidden Markov models). Topics covered will include protein and DNA sequence alignments, evolutionary analysis and phylogenetic trees, obtaining protein secondary structure from sequence, and analysis of gene expression including clustering methods.
Recommended background: BB 2920, BB 2950, and MA 2610 or 2611.
This course will be offered in 2012-13 and in alternating years thereafter.

BCB 4002. BIOVISUALIZATION. Cat. II
This course will use interactive visualization to model and analyze biological information, structures, and processes. Topics will include the fundamental principles, concepts, and techniques of visualization (both scientific and information visualization) and how visualization can be used to study bioinformatics data at the genomic, cellular, molecular, organism, and population levels. Students will be expected to write small to moderate programs to experiment with different visual mappings and data types. Recommended background: CS 2102, CS 2223, and one or more biology courses. This course will be offered in 2012-13 and in alternating years thereafter.

BCB 4003. BIOLOGICAL AND BIOMEDICAL DATABASE MINING. Cat. II
This course will investigate computational techniques for discovering patterns in and across complex biological and biomedical sources including genomic and proteomic databases, clinical databases, digital libraries of scientific articles, and ontologies. Techniques covered will be drawn from several areas including sequence mining, statistical natural language processing and text mining, and data mining. Recommended Background: CS 2102, CS 2223, MA 2610 or MA 2611, and one or more biology courses. This course will be offered in 2011-12 and in alternating years thereafter.

BCB 4004. STATISTICAL METHODS IN GENETICS AND BIOINFORMATICS. Cat. II
This course provides students with knowledge and understanding of the applications of statistics in modern genetics and bioinformatics. The course generally covers population genetics, genetic epidemiology, and statistical models in bioinformatics. Specific topics include meiosis modeling, stochastic models for recombination, linkage and association studies (parametric vs. nonparametric models, family-based vs. population-based models) for mapping genes of qualitative and quantitative traits, gene expression data analysis, DNA and protein sequence analysis, and molecular evolution. Statistical approaches include log-likelihood ratio tests, score tests, generalized linear models, EM
algorithm, Markov chain Monte Carlo, hidden Markov model, and classification and regression trees. Recommended background: MA 2612, MA 2631 (or MA 2621), and BB 2920.

This course will be offered in 2011-12 and in alternating years thereafter.

**BIOLOGY AND BIOTECHNOLOGY**

**BB 1001. INTRODUCTION TO BIOLOGY.**

*Cat. I*

This course consists of an overview of the major concepts of Biology, including: cell theory, bioenergetics, molecular biology, reproduction, nutrition, growth, development, homeostatic controls, and ecological issues. This course is intended for students seeking a broad overview of contemporary Biology with emphasis on human issues and current topics.

Recommended background: high school or introductory college level chemistry.

**BB 1002. ENVIRONMENTAL BIOLOGY.**

*Cat. I*

This course provides an introduction to natural ecosystems, population growth, and the interaction between human populations and our environment. Major areas of discussion include Ecosystems, Populations, Biodiversity, Pollution, and Environmental Economics. This course is designed for students seeking a broad overview of ecological systems and the effect of humans on the ecosystems.

Recommended background: High School biology.

**BB 1025. HUMAN BIOLOGY.**

*Cat. I*

This course presents students with an introduction to general concepts of human biology with particular focus on human structure and function. Contemporary issues of homeostasis, ergonomics, adaptation and health will be discussed in the context of today’s emerging environmental and inter-organism impacts on the quality of life. Scientific background will underscore student opportunities to think critically, from the perspective of the human organism functioning independently, the interface between the individual and the immediate environment, including interactive relationships with technology, and global environment.

Recommended background: High School biology and chemistry.

**BB 1035 INTRODUCTION TO BIOTECHNOLOGY.**

*Cat. I*

Current topics and issues in Biotechnology will be investigated. Some examples of topics which may be investigated in detail include: cloning, DNA fingerprinting and molecular forensics, transgenic organisms, green engineering and bio-mediation, bioprocess and metabolic engineering, bioinformatics, and mathematical modeling of biological systems.

Recommended background: high school biology or equivalent.

**BB 1045 BIODIVERSITY.**

*Cat. I*

This course is an integrated survey of the five kingdoms which stresses general concepts and economically important species. Particular attention will be paid to special structures and mechanisms evolved by selected representatives of major phyla of plants and animals for solving problems of life in various environments.

Recommended background: high school biology or equivalent.

**BB 2002. MICROBIOLOGY.**

*Cat. I*

This course will focus on unicellular organisms with special reference to those of the domain Bacteria, and describe their taxonomy, morphology, and physiology. Special attention will be given to those organisms that are of ecological concern or serve a useful industrial purpose. The importance of microbes and viruses in public health will be presented. This course is designed for all biology majors and other students who seek a good general education in modern biology.

Recommended background: A basic understanding of cell biology and elementary biochemical processes is desired.

**BB 2030. PLANT DIVERSITY.**

*Cat. I*

An introductory course stressing general concepts related to the vast array of plant species, taxonomic links, and uses of major plant phyla in both society and industry. Some emphasis will be given to economically important species chosen from agronomic and non-agronomic situations.

Recommended background: BB 1045. Students may not receive credit for both BB 2030 and BB 2040.

**BB 2040. PRINCIPLES OF ECOLOGY.**

*Cat. I*

This course is designed to give the student a basis for understanding the abundance and distribution of plants and animals from the level of the individual to that of the ecosystem. Topics may include population ecology, competition, community ecology, patterns of species diversity, and energy flow.

Recommended background: BB 1045, and MA 1021-1022.

**BB 2550. CELL BIOLOGY.**

*Cat. I*

This entry level course, recommended for all BIO, BC, and pre-professional majors, presents the fundamental aspects of cell structure and function, and is the foundation of all fields of modern biology.

Topics include: cell complexity and organizational hierarchy, evolution of the cell, cell surface, plasma membrane, single and double cytoplasmic membrane systems, nuclear fusion and hybridomas, cytoskeleton, cell growth, and differentiation.

Recommended background: BB 1001, BB 1035, or equivalent.

**BB 2920. GENETICS.**

*Cat. I*

This course presents the principles and experimental evidence leading to our understanding of the gene concept and the role of DNA as genetic material. Patterns of inheritance, the relationship between genotype and phenotype, and transmission, coding, and expression of genetic information are considered in a variety of organisms. A quantitative, problem-solving approach and the use of genetic analysis as a tool to study biological phenomena are emphasized throughout the course. The course is designed for all biology and pre-professional majors.

Recommended background: BB 1035.

**BB 2950. MOLECULAR BIOLOGY.**

*Cat. I*

This course will explore the molecular mechanisms by which cells use genetic information to produce RNAs and proteins. Mechanisms and regulation of transcription in both prokaryotes and eukaryotes will be studied with an emphasis on protein-protein and protein-DNA interactions. The structure, organization, evolution and expression of the eukaryotic genome will be emphasized.

Recommended background: BB 1035 or equivalent.

**BB 3040. EXPERIMENTAL DESIGN AND DATA ANALYSIS.**

*Cat. II*

This applied course introduces students to the design of experiments and analysis of data. We will cover a number of experimental situations occurring frequently in biology, including testing the fit of data to theoretical distributions, comparisons of groups, and regression analysis. Emphasis will be placed on formulating the hypothesis of interest, designing experiments so that the subsequent analysis will have enough power to test the hypothesis, and choosing the appropriate analysis to perform. We will discuss the importance of pilot studies, and some of the most common errors made in choosing and performing statistical tests. Both parametric and non-parametric tests will be discussed.

Students will use computer packages to analyze data from the literature and/or their own experimental data.

Recommended background: MA 2611, and any 3000 or 4000 level BB course. Offered in 2012-13 and in alternating years thereafter.

Note: Students who have credit for BB 4040 may not receive credit for BB 3040.

**BB 3055. MICROBIAL PHYSIOLOGY.**

*Cat. I*

This course will focus on the metabolic (enzymatic) pathways by which microorganisms obtain, process, and store substances and energy used for synthesis; and on the synthetic pathways by which these substances and energy are utilized. The occurrence of biological reactions in the light of the particular organism and its environment will be emphasized, as well those organisms and metabolic schemes of current or potential usefulness in bioprocess technology.

Recommended background: BB 2002, BB 2550. Students who have taken BB 4050 for credit will not receive credit for BB 3055.
BB 3080. NEUROBIOLOGY. Cat. I
An introduction to neurobiology, with emphasis on the cellular and molecular basis of neural development and function. Topics will range from electrical and biochemical signaling between neurons, to higher order functions of the nervous system, such as sensation, movement, and memory. Human neurological diseases and disorders will be discussed. Some guided reading of the primary literature will be included.
Recommended background: BB 2550, BB 2920, and BB 3101.
Students may not receive credit for both BB 4080 and BB 3080.

BB 3101. HUMAN ANATOMY & PHYSIOLOGY: MOVEMENT AND COMMUNICATION. Cat. I
The form and function of the systems that are responsible for the support, movement, internal communication, and interaction of the human body with its environment will be presented and discussed: Integumentary, Skeletal, Muscular, Nervous (including the senses), and Endocrine.
Recommended background: BB 2550 Cell Biology or BB 1001, Introduction to Biology. Suggested background: Concurrent Laboratory Module: BB 3511 (Nerve and Muscle Physiology), Students who have received credit for BB2130 (Human Anatomy) may not take BB3101 for credit.

BB 3102. HUMAN ANATOMY & PHYSIOLOGY: TRANSPORT AND MAINTENANCE. Cat. I
The form and function of the systems of the human body that provide for the intake, distribution, and processing of nutrients, water, and oxygen, and the systems that safeguard health by elimination of wastes, regulation of metabolism, and surveillance against disease will be presented and discussed: Digestive, Respiratory, Circulatory, Lymphatic, Endocrine, Urinary, and Reproductive.
Recommended background: BB 2550 Cell Biology or BB 1001 (Introduction to Biology) or BB 1035 (Introduction to Biotechnology); CH 1010 and CH 1020 (General Chemistry). Suggested background: Concurrent Laboratory Module: BB 3514 (Circulatory and Respiratory Physiology). Students who have received credit for BB 3110 (Animal Physiology) may not take BB 3102 for credit.

BB 3120. PLANT PHYSIOLOGY AND CELL CULTURE. Cat. II
The relationship of structure and function of multicellular plants will be examined at the biochemical level. Topics include (but are not limited to): water relations, mineral nutrition, intra- and inter-cellular transport, hormones, photosynthesis, in vitro culture of plant cells/tissues/ organs, and environmental responses.
Recommended background: BB 1045, BB 2550, CH 1020.
This course will be offered in 2012-13 and in alternating years thereafter.

BB 3140. EVOLUTION: PATTERN AND PROCESS. Cat. II
We will explore several theoretical constructs of evolutionary processes. Topics will range from microevolutionary patterns to global extinctions and speciation. We will examine the causes of evolutionary trends from the molecular to the group level. Readings from current research into the units and levels of selection will be included.
Recommended background: BB 2550, BB 2920, at least one of (BB 1045, BB 2040).
This course will be offered in 2011-12 and in alternating years thereafter.

BB 3620. DEVELOPMENTAL BIOLOGY. Cat. II
This advanced level course provides a detailed survey of the processes of animal development, including fertilization, cleavage, gastrulation, and organogenesis. These processes are examined in the context of concepts such as differentiation, determination, induction, intercellular signaling, morphogenesis, and pattern formation. Emphasis is placed on current techniques for studying development, such as genetic analysis of mutations, recombinant DNA technology, molecular probing of gene expression, and gene transfer. The experimental focus is on model organisms such as nematodes, fruit flies, frogs, and mice.
Offered in 2011-12 and in alternating years thereafter.
Recommended background: BB 2002, BB 2550, BB 2920.

BB 3920. IMMUNOLOGY. Cat. I
This is a survey course in immunology which assumes a background in cell biology, genetics and biochemistry. Topics to be covered will include cells of the immune system, antigen/antibody immunochemistry, immunogenetics and immune responses. Readings from research literature will be assigned.
Recommended background: BB 2550, BB 2920, CH 4110, and CH 4120.

BB 4008. CELL CULTURE THEORY AND APPLICATIONS. Cat. I
The use of cultured animal cell systems for research and production will be explored. Concepts, including media design, the effects of extracellular matrices, scaling up of cell cultures, and biochemical and morphologic assessment of cell function, will be discussed as a basis for readings from the literature.
Recommended background: BB 2550, BB 2920, CH 4110, and CH 4120.
Students who have received credit for BB 4007 may not take BB 4008 for credit.

BB 4010. ADVANCED MOLECULAR GENETICS. Cat. I
Topics in molecular genetics are presented using microbial systems as models. The structure, function and synthesis of DNA and the results of mutation, recombination and repair are emphasized. Simple bacteria and their plasmids, transposable elements and plages are discussed as experimental models.
Recommended background: BB 2002, BB 2550, BB 2920, BB 4910.

BB 4065. VIROLOGY. Cat. I
This advanced-level course uses a seminar format based on research articles to discuss current topics related to the molecular/cell biology of viral structure, function, and evolution. Particular emphasis is placed on pathological mechanisms of various human disorders, especially emerging diseases, and the use of viruses in research.
Recommended background: BB 2550.

BB 4150/BB 515. ENVIRONMENTAL CHANGE: PROBLEMS & APPROACHES Cat II
This seminar course will examine what is known about ecological responses to both natural and human-mediated environmental changes, and explore approaches for solving ecological problems and increasing environmental sustainability. Areas of focus may include, and are not limited to, conservation genetics, ecological responses to global climate change, sustainable use of living natural resources, and the environmental impacts of agricultural biotechnology.
Recommended background: BB 1045, BB2040, ENV1100.
This course will be offered in 2012-13 and in alternating years thereafter.

BB 4550. ADVANCED CELL BIOLOGY. Cat. I
This advanced-level course uses a seminar format based on research articles to discuss current topics related to the molecular biology of cellular function. Particular emphasis is placed on biological mechanisms of autoimmune disorders, Alzheimers disease, DNA vaccines, stem cells, animal cloning, neurotropic factors, and gene therapy.
Recommended background: BB 2550.

IS4 BB. SPECIAL TOPICS. Cat. I
Experimental courses, special conferences and seminars are offered by advance arrangement only.

BIOLoGY AND BIOTECHNOLOGY LAB COURSES

BB 2901. MOLECULAR BIOLOGY, MICROBIOLOGY, AND GENETICS. Cat. I (1/6 unit)
The lab exercises in this course are designed to provide foundation skills needed for the study of living organisms and systems at the both the organismal and molecular scales. Students will gain experience with procedures, equipment, techniques and skills common to all areas of biology. In particular this course will focus on:

BB 2902. ENZYMES, PROTEINS, AND PURIFICATION. Cat. I (1/6 unit)
The lab exercises in this course are designed to provide foundation skills needed for the study of living organisms and systems at both the organismal and molecular scales. Students will gain experience with procedures, equipment, techniques and skills common to all areas of biology. In particular this course will focus on:
The action and optima of enzyme action
Quantification and detection techniques for proteins
Extraction and purification of protein from biological material
Recommended background: One or more 1000/2000 BB courses

BB 2903. ANATOMY AND PHYSIOLOGY.
Cat. I (1/6 unit)
The lab exercises in this course are designed to provide foundation skills needed for the study of living organisms and systems at the both the organismal and molecular scales. Students will gain experience with procedures, equipment, techniques and skills common to all areas of biology. In particular this course will focus on:
Comparative and general anatomy of several organisms
Physiology and function of body systems, processes and organs.
Recommended background: One or more 1000/2000 BB courses

BB 2904. ECOLOGY, ENVIRONMENT, AND ANIMAL BEHAVIOR.
Cat. I (1/6 unit)
The lab exercises in this course are designed to provide foundation skills needed for the study of living organisms and systems at the both the organismal and molecular scales. Students will gain experience with procedures, equipment, techniques and skills common to all areas of biology. In particular this course will focus on:
Observing, recording, understanding, and analyzing animal behaviors
Environmental and Ecological assessment and sampling
Observations of population dynamics
Recommended background: One or more 1000/2000 BB courses

BB 3511. NERVE AND MUSCLE PHYSIOLOGY.
Cat. I (1/6 unit)
Computer and laboratory studies of nerve and muscle function.
Recommended background: BB 2940, or BB 2903.
Concurrent or prior registration in BB 3101 is recommended.

BB 3512. MOLECULAR GENETICS LAB.
Cat. I (1/6 unit)
The topic of gene therapy will be used to familiarize the student with computer cloning and manipulations of biological sequence information.
Recommended background: BB 2920, BB 2550 and BB 4910/CH 4130.

BB 3513. CELL CULTURE TECHNIQUES FOR ANIMAL CELLS.
Cat. I (1/6 unit)
Basic laboratory skills in mammalian cell culture to include cell counting, freezing and thawing cell lines, culture of suspension and attached cells.
Recommended background: BB 2901, BB 2550 and knowledge of aseptic techniques.
Concurrent or prior registration in BB 4008 is recommended.

BB 3514. CIRCULATORY AND RESPIRATORY PHYSIOLOGY.
Cat. I (1/6 unit)
Computer and laboratory studies of circulatory and respiratory physiology.
Recommended background: BB 2940, or BB 2903.
Concurrent or prior registration in BB 3102 is recommended.

BB 3516. SEPARATION TECHNIQUES IN BIOTECHNOLOGY.
Cat. I (1/6 unit)
A laboratory course in chromatographic and electrophoretic separation of proteins; plasmid isolation, restriction digestion and electrophoretic separation of DNA.
Recommended background: BB 2940, or BB 2902.
Concurrent or prior registration in Biochemistry (CH 4110) and BB 4910 is recommended.

BB 3517. FERMENTATION.
Cat. I (1/6 unit)
An introductory laboratory course in basic fermentation techniques.
Recommended background: BB 2940 or BB 2901, BB 2002, or knowledge of aseptic techniques.
Concurrent or prior registration in BB 3055 is suggested.

BB 3518. MOLECULAR BIOLOGY.
Cat. I (1/6 unit)
Laboratory investigations of select molecular characteristics of proteins and DNA.
Recommended background: BB 2940 or BB 2901, BB 2550, and CH 4110.
Concurrent, or prior registration in BB 4910 or CH 4130 is recommended.

BB 3519. PROTEIN PURIFICATION.
Cat. I (1/6 unit)
A laboratory course in protein purification techniques.
Recommended background: BB 2940 or BB 2902, CH 4110.
Concurrent or prior registration in BB 4070 is recommended.

BB 3520. RECOMBINANT DNA TECHNOLOGY.
Cat. I (1/6 unit)
A laboratory course in the construction, isolation and mapping of recombinants, and use of the polymerase chain reaction.
Recommended background: BB 2940 or BB 2901, BB 2550, CH 4110 and BB 4910.
Concurrent or prior registration in BB 4955 is recommended.

BB 3521. MICROSCOPY.
Cat. I (1/6 unit)
A laboratory course in the theory and operation of light and electron microscopes, including specimen preparation, operation of equipment, and microphotography.
Recommended background: BB 2940 or BB 2901, and BB 2550.

BB 3522. TRANSMISSION ELECTRON MICROSCOPY.
Cat. I (1/6 unit)
This laboratory module will provide the student with the basic theory and practice of transmission electron microscopy. The course will include sample handling and preparation methods, use of the TEM, and photographic recording of observations made with the instrument.
Recommended background: BB 1001 or BB 2550, and BB 2940 or BB 2950 or BB 2901 or BB 2903.

BB 3524. BIOINFORMATICS LAB.
Cat. I (1/6 unit)
Laboratory course investigating some of the basic tools currently available for sequence date mining, comparison of nucleotide and/or protein sequences, and the analysis of nucleotide and protein sequences. Course will be computer based.
Recommended background: BB2920, BB2901, and CH4110.
Concurrent or prior registration in BB4950 or CH4130 is recommended.
Students who have received credit for BB324X may not receive credit for BB3524.

BB 3525. PLANT PHYSIOLOGY.
Cat. I (1/6 unit)
Basic studies in the biochemical and physical systems plants use to sustain life; includes an introduction to plant cell culture techniques.
Recommended background: BB1045 and BB2903.
Concurrent or prior registration in BB3120 is recommended. Students who have received credit for BB 325X may not receive credit for BB3525.

Graduate Biology and Biotechnology Courses of Interest to Undergraduates

The following courses are open to advanced undergraduates with special written permission of the course instructor and department head.

BB 501. SEMINAR.

BB 509. SCALE-UP OF BIOPROCESSING.
Strategies for optimization of bioprocesses for scale-up applications. In addition to the theory of scaling up unit operations in bioprocessing, students will scale-up a bench scale bioprocess (5 liters) including fermentation and downstream processing to 55 liters. Specific topics include the effects of scaling-up on: mass transfer and bioreactor design, harvesting techniques including tangential flow filtration and centrifugation, and chromatography (open column and HPLC).
Recommended courses include BB 3055 Microbial Physiology and BB 4070/60 Separations of Biological Molecules, as a working knowledge of the bench scale processes will be assumed. Otherwise, instructor permission is required.

BB 542. ECOLOGICAL SIMULATION MODELING.
This course will cover computer simulation modeling of populations, bioenergetics, behavior of individuals, and ecosystem dynamics. Modeling techniques covered will range from simple linear models of populations and interactions between ecosystem components to individual-based models of populations in complex environments. Students successfully completing the course should be capable of understanding models used in today's study of populations and ecosystems and of developing original models. Knowledge of a programming language is assumed.
BB 560. SEPARATION OF BIOLOGICAL MOLECULES.
This course provides a detailed hands-on survey of state-of-the-art methods employed by the biotechnology industry for the purification of products, proteins in particular, from fermentation processes. Focus is on methods which offer the best potential for scale-up. Included are the theory of the design as well as the operation of these methods both at the laboratory scale as well as scaled up. It is intended for biology, biotechnology, chemical engineering, and biochemistry students. A knowledge of basic biochemistry is assumed.

BB 565. VIROLOGY.
This advanced-level course uses a seminar format based on research articles to discuss current topics related to the molecular/cell biology of viral structure, function, and evolution. Particular emphasis is placed on pathological mechanisms of various human disorders, especially emerging diseases, and the use of viruses in research.

BB 570. SPECIAL TOPICS.
Specialty subjects are offered using the research expertise of the department faculty. Content and format varies to suit the interest and needs of the faculty and students. This course may be repeated for different topics covered.

BB 575. ADVANCED GENETICS & CELL BIOLOGY.
Topics in this course focus on the basic building blocks of life; molecules, genes and cells. The course will address areas of the organization, structure, function and analysis, of the genome and of cells. Required Background: Students in the course should be familiar with the fundamentals of recombinant DNA and molecular biological techniques as well as cell biology.

BB 576. ADVANCED INTEGRATIVE BIOSCIENCE.
This course concentrates on the organization of cells into biological systems and into individual organisms. Discussion will center on the development and function of specific model systems such as the nervous and immune systems. Required background: Students in the course should be familiar with the fundamentals of developmental biology, genetics and cell biology.

BB 577. ADVANCED ECOLOGICAL & EVOLUTIONARY BIOSCIENCE.
This course will explore the organization of individuals into communities, and the evolution of individual traits and behaviors. Problems discussed will range from those of population harvesting and the effect humans have on the environment to the evolution of disadvantageous traits. Required background: Students should be familiar with fundamentals of population interactions, evolution and animal behavior.

BB 578. ADVANCED APPLIED BIOTECHNOLOGY.
This course examines the use of biotechnological advances towards solving real world problems. Students will discuss problem-solving strategies from the current literature in the areas of medicine, agriculture, environmental protection/restoration and industrial biotechnology. Required background: Students should be familiar with biochemistry, microbiology, and plant and animal physiology.

BME 2210. BIOMEDICAL SIGNALS, INSTRUMENTS AND MEASUREMENTS.
Cat. I
This course is an introduction to the instrumentation methods used to measure, store and analyze the signals produced by biomedical phenomena. The goal of this course is to familiarize students with the basic design and implementation of techniques for measuring a broad scope of signal types for molecular, cellular and physiological research. Students will get an introduction to the origins and characteristics of the electric and electromagnetic signals that arise in biological tissues. Sensors used for acquiring electrical, magnetic, optical/spectral and chemical signals will be covered. Topics include the underlying physics and chemistry of biomedical signals, biosensor types and usage, amplification and signal conditioning, data acquisition methods, basic signal processing methods, the origins of artifact and noise, and programming methods.
Recommended background: MA 1024, PH 1120/21
Students who have received credit for BME 2204 may not receive credit for BME 2210.

BME 2211. BIOMEDICAL DATA ANALYSIS/PROGRAMMING.
Cat. I
To learn the fundamental of linear time series analyses framework for modeling and mining biological data. Applications range from cardio-respiratory, renal blood pressure/flow to mechanical stress/strain data. Tools of data analysis include Laplace transforms, convolution, correlation, sampling theorem, Fourier transform, transfer function, coherence function, statistics, and various filtering techniques. The goal of this course is to offer the students an opportunity to learn and model and simulate static and dynamic physiological systems using linear systems theory. First principles of chemistry and physics are used to quantitatively model physiological systems. Most of the models are based on lumped systems theory. Simulations and estimation are performed using Matlab and already-developed software.
Recommended background: MA 1024, BME 2210, CS 1101 or equivalent.
Students who have received credit for BME 2204 may not receive credit for BME 2211.

BME 2511. INTRODUCTION TO BIOMECHANICS AND BIOTRANSPORT.
Cat. I
This course is an introduction to the analysis of physiological systems using principles of biomechanics including statics, stress analysis, and transport phenomena. Basic theories of static equilibrium, stress analysis, momentum transport, mass transport and energy transport are presented and applied to cellular and mammalian physiology. Principles of biomechanics transport phenomena are also applied to the design of medical devices and bioengineered tissues. Topics include forces, moments, free body diagrams, principal stresses, viscoelasticity, differential and integral balances, rheology of Newtonian and non-Newtonian fluids, diffusion in reacting systems and homogeneous vs. heterogeneous reaction systems.
Recommended background: MA 2501, PH 1120 or PH 1121.
Students who have previously received credit for BME 2504 or BME 2604 may not receive credit for BME 2511.

BME 2811. INTRODUCTION TO BIOMATERIALS SCIENCE AND TISSUE ENGINEERING.
Cat. I
This course provides an introduction to the characterization, analysis and design of biomaterials for the purposes of correcting deformities, restoring lost function or promoting tissue regeneration in the human body. The principles of materials science, specifically the fundamental structure-function relationships of biomaterials will be explored, as they relate to the use of materials in the body. The course will also examine properties of biomaterials as they relate to minimizing corrosion, controlling degradation and tailoring cell-material interaction to guide cell growth and tissue regeneration. Topics include structural properties of materials, characterization of materials, tissue responses to implants and designing materials for tissue engineering.
Recommended background: PH 1110, CH 1110, BB 2550, ES2001 or equivalent.

BME/ECE 3011. BIOMEDICAL ELECTRONICS AND BIOSENSORS.
Cat. I
A study of the basic principles of biomedical electronics and measurement with emphasis on the operational performance and selection of transducers, instruments and systems for biomedical data acquisition and processing. Biopotential electrodes. Analysis and selection of physical, optical, electrical, mechanical, thermal transduction mechanisms which form the basis of the sensor design. Clinical laboratory instrumentation. Electrical safety problems in the clinical environment.
Recommended background: MA 2051, ECE 3601, or equivalent.
BME 3111. PHYSIOLOGY AND ENGINEERING.
Cat. I
This course provides students with an understanding of mammalian physiology and the engineering aspects of different physiological systems. The course will have both a lecture and laboratory portion. The laboratory portion will provide the students with the ability to analyze and interpret data from living systems, which is a required ABET program criteria for student majoring in Biomedical Engineering. The course will focus on a number of organ systems that may include cardiovascular, respiratory, and renal. Engineering principles that include biomechanical, bioelectrical, and biofluids will be applied to physiological systems.

Recommended background: A knowledge of biomechanics (BME 2504), biological transport (BME 2604) and bioelectric foundations (BME 2204).

BME 3300. BIOMEDICAL ENGINEERING DESIGN.
Cat. I
Students are guided through the open-ended, real-world, design process starting with the project definition, specification development, management, team interactions and communication, failure and safety criteria, progress reporting, marketing concepts, documentation and technical presentation of the final project outcome. The course will include a significant writing component, will make use of computers, and hands-on design explorations.

Students who have previously received credit for BME 2300 may not receive credit for BME 3300.

BME 3504. EXPERIMENTAL BIOMECHANICS.
Cat. I
This laboratory-driven biomechanics course provides hands-on experience in characterizing the mechanical properties of hard and soft biological tissues. Students gain an in-depth understanding of the course material from personal observations and measurements on actual soft and hard tissues using industry-standard testing equipment. Challenge-based laboratory projects will be assigned which will require the students to determine and execute effective test methods in teams at their own pace. Tissues tested may include blood vessels, cartilage, bone, tendons, skin, and muscle.

Recommended background: A solid knowledge of mechanics of materials (BE 2504 or ES2502), and material science (ES 2001).

BME/ECE 4011. BIOMEDICAL SIGNAL ANALYSIS.
Cat. II
Introduction to biomedical signal processing and analysis. Fundamental techniques to analyze and process signals that originate from biological sources: ECGs, EMGs, EEGs, blood pressure signals, etc. Course integrates physiological knowledge with the information useful for physiologic investigation and medical diagnosis and processing. Biomedical signal characterization, time domain analysis techniques (transfer functions, convolution, auto- and cross-correlation), frequency domain (Fourier analysis), continuous and discrete signals, deterministic and stochastic signal analysis methods. Analog and digital filtering.

Recommended background: ECE 2311, ECE 2312, BME 3011, or equivalent.

This course will be offered in 2012-13, and in alternating years thereafter.

BME 4023. BIOMEDICAL INSTRUMENTATION DESIGN.
Cat. II
This course builds on the fundamental knowledge of bioinstrumentation and biosensors presented in BME 3011. Lectures and hands-on laboratory experiments cover the principles of designing, building and testing analog instruments to measure biological events. Design laboratories will include biopotential amplifiers and biosensor/bioinstrumentation systems for the measurement of physiological parameters.

Recommended background: BME 2204, BME 3011, ECE 2011, and ECE 2111.

This course will be offered in 2011-12, and in alternating years thereafter.

BME 4201. BIOMEDICAL IMAGING.
Cat. II
This course is a practical introduction to biomedical image processing using examples from various branches of medical imaging. Topics include point operations, filtering in the image and Fourier domains, image reconstruction in computed tomography and magnetic resonance imaging, and data analysis using image segmentation. Review of linear-systems theory and the relevant principles of physics. Course work uses examples from microscopy, computed tomography, X-ray radiography, and magnetic resonance imaging. A working knowledge of undergraduate signal analysis and linear algebra is desirable. Facility with a high-level programming language is recommended.

The course will be offered in 2012-13, and in alternating years thereafter.

BME/ME 4504. BIOMECHANICS.
Cat. II
This course emphasizes the applications of mechanics to describe the material properties of living tissues. It is concerned with the description and measurements of these properties as related to their physiological functions. Emphasis on the interrelationship between biomechanics and physiology in medicine, surgery, body injury and prostheses.

Topics covered include: Review of basic mechanics, stress, strain, constitutive equations and the field equations, viscoelastic behavior, and models of material behavior. The measurement and characterization of properties of tendons, skin, muscles and bone. Biomechanics as related to body injury and the design of prosthetic devices.

Recommended background: Mechanics (ES 2501, ES 2502, ES 2503, ME 3501), Mathematics (MA 2051).

This course will be offered in 2011-12, and in alternating years thereafter.

BME/ME 4606. BIOFLUIDS.
Cat. II
This course emphasizes the applications of fluid mechanics to biological problems. The course concentrates primarily on the human circulatory and respiratory systems. Topics covered include: blood flow in the heart, arteries, veins and microcirculation and air flow in the lungs and airways. Mass transfer across the walls of these systems is also presented.

Recommended background: ME 3501 and fluid mechanics equivalent to ES 3004.

This course will be offered in 2012-13, and in alternating years thereafter.

BME 4701. CELL AND MOLECULAR BIOENGINEERING.
Cat. I
This course examines the principles of cellular and cell biology applied to the design of engineered molecules, cells and tissues. Topics will include the basic structural, chemical and physical properties of biomolecules (proteins, lipids, DNA and RNA), application of biomolecules to monitor and alter cellular processes in vitro and in vivo, and design considerations for engineering cell and molecular therapeutics. Case studies will be used to examine specific applications of molecular and cellular bioengineering technologies to treat disease and promote tissue repair and regeneration.

Recommended background: A solid understanding of cell biology (BB 2550).

Additional coursework in molecular biology (BB 2950) and/or genetics (BB 2920) would be beneficial.

Students who earned credit for BME 37XX cannot receive credit for BME 4701.

BME/ME 4814. BIOMATERIALS.
Cat. I
A course discusses various aspects pertaining to the selection, processing, testing (in vitro and in vivo) and performance of biomedical materials. The biocompatibility and surgical applicability of metallic, polymeric and ceramic implants and prosthetic devices are discussed. The physico-chemical interactions between the implant material and the physiological environment will be described. The use of biomaterials in maxillofacial, orthopedic, dental, ophthalmic and neuromuscular applications is presented.

Recommended background: BB 3130 or equivalent introduction to Human Anatomy, ES 2001 or equivalent introduction to Materials Science and Engineering.

BME 4828. BIOMATERIALS-TISSUE INTERACTIONS.
Cat. I
This course examines the principles of materials science and cell biology underlying the design of medical devices, artificial organs and scaffolds for tissue engineering. Molecular and cellular interactions with biomaterials are analyzed in terms of cellular processes such as matrix synthesis, degradation and contraction. Principles of wound healing and tissue remodeling are used to study biological responses to implanted materials and devices. Case studies will be analyzed to compare tissue responses to intact, bioreabsorable and bioerodible biomaterials. Additionally, this course will examine criteria for restoring physiological function of tissue and organs and investigate strategies to design implants and prostheses based on control of biomaterial-tissue interactions.

Recommended background: BB 2550 or equivalent, ES 2001 or equivalent, PH 1110 or PH 1111.
**Graduate Biomedical Engineering Courses of Interest to Undergraduates**

**BME 523. BIOMEDICAL INSTRUMENTATION.**
Origins and characteristics of bioelectric signals, recording electrodes, amplifiers, chemical pressure and flow transducers, noninvasive monitoring techniques, and electrical safety. (Prerequisite: Circuits and electronics, control engineering or equivalent.)

**BME 531. BIOMATERIALS IN THE DESIGN OF MEDICAL DEVICES.**
Biomaterials are an integral part of medical devices, implants, controlled drug delivery systems, and tissue engineered constructs. Extensive research efforts have been expended on understanding how biologic systems interact with biomaterials. Meanwhile, controversy has revolves around biomaterials and their availability as a result of the backlash to the huge liability resulting from controversies related to material and processing shortcomings of medical devices. This course specifically addresses the unique role of biomaterials in medical device design and the use of emerging biomaterials technology in medical devices. The need to understand design requirements of medical devices based on safety and efficacy will be addressed. Unexpected device failure can occur if testing fails to account for synergistic interactions from chronic loading, aqueous environments, and biologic interactions. Testing methodologies are readily available to assess accelerated effects of loading in physiologic-like environments. This combined with subchronic effects of animal implants is a potential tool in assessing durability. It is difficult to predict the chronic effects of the total biologic environment. The ultimate determination of safety comes not only from following the details of regulations, but with an understanding of potential failure modes and designs that lower the risk of these failures. This course will evaluate biomaterials and their properties as related to the design and reliability of medical devices.

**BME 532. MEDICAL DEVICE REGULATION.**
This course provides an overview of regulations that guide the Medical Devices industry. Primary focus is on the Food, Drug and Cosmetic Act and its associated regulations. The course covers the FD&C Act, including definitions, prohibited acts, penalties and general authority. The course also covers regulations, including establishment registration, premarket approval (PMA), and current good manufacturing practices. Requirements of other federal agencies (NRC, FCC, EPA) will also be discussed.

**BME/ME 550. TISSUE ENGINEERING.**
This biomaterials course focuses on the selection, processing, testing and performance of materials used in biomedical applications with special emphasis upon tissue engineering. Topics include: material selection and processing, mechanisms and kinetics of material degradation, cell-material interactions and interfaces; effect of construct architecture on tissue growth; and transport through engineered tissues. Examples of engineering tissues for replacing cartilage, bone, tendons, ligaments, skin and liver will be presented. (Recommended preparation: A first course in biomaterials equivalent to BME/ME 4814 and a basic understanding of physiology and cell biology.)

**BME/ME 552. TISSUE MECHANICS.**
This biomechanical course focuses on advanced techniques for the characterization of the structure and function of hard and soft tissues and their relationship to physiologic processes. Applications include: tissue injury, wound healing, the effect of pathological conditions upon tissue properties and design of medical devices and prostheses. (Recommended preparation: A first course in biomechanics equivalent to BME/ME 4504.)

**BME/ME 554. COMPOSITES WITH BIOMEDICAL AND MATERIALS APPLICATIONS.**
Introduction to fiber/particulate reinforced, engineered and biologic materials. This course focuses on the elastic description and application of materials that are made up of a combination of submaterials, i.e., composites. Emphasis will be placed on the development of constitutive equations that define the mechanical behavior of a number of applications, including: biomaterial, tissue, and materials science. (Prerequisites: understanding of stress analysis and basic continuum mechanics.)

**BME/ME 558. BIOFLUIDS AND BIOTRANSPORT.**
The emphasis of this course is on modeling fluid flow within the cardiovascular and pulmonary systems and the transport processes that take place in these systems. Applications include artificial heart valves, atherosclerosis, arterial impedance matching, clinical diagnosis, respiration, aerosol and particle deposition. Depending upon class interest, additional topics may include: reproductive fluids, animal propulsion in air and water and viscoelastic testing. (Recommended preparation: A first course in biofluids equivalent to BME/ME 4606.)

**BME 560. PHYSIOLOGY FOR ENGINEERS.**
An introduction to fundamental principles in cell biology and physiology designed to provide the necessary background for advanced work in biomedical engineering. Quantitative methods of engineering and the physical sciences are stressed. Topics include cell biology and the physiology of major organ systems. NOTE: This course can be used to satisfy a life science requirement in the biomedical engineering graduate program. It cannot be used to satisfy a biomedical engineering course requirement.

**BME 562. LABORATORY ANIMAL SURGERY.**
A study of anesthetics, surgical techniques, and postoperative care in small laboratory animals. Anatomy and physiology of species used included as needed. Class limited to 15 students. Approximately 15 surgical exercises are performed by each student. NOTE: This course can be used to satisfy a life science requirement in the biomedical engineering graduate program. It cannot be used to satisfy a biomedical engineering course requirement.

**BME 581. MEDICAL IMAGING SYSTEMS.**
Overview of the physics of medical image analysis. Topics covered include X-Ray tubes, fluoroscopic screens, image intensifiers; nuclear medicine; ultrasound; computer tomography; nuclear magnetic resonance imaging. Image quality of each modality is described mathematically, using linear systems theory (Fourier transforms, convolutions). (Prerequisite: Signal analysis course ECE 2532 or equivalent.)

**BME 582. PRINCIPLES OF IN VIVO NUCLEAR MAGNETIC RESONANCE IMAGING.**
This course emphasizes the applications of Fourier transform nuclear magnetic resonance (FTNMR) imaging and spectroscopy in medicine and biology. Course topics include: review of the basic physical concepts of NMR (including the Bloch equations), theoretical and experimental aspects of FTNMR, theory of relaxation and relaxation mechanisms in FTNMR, instrumentation for FTNMR, NMR imaging techniques (point, line, plane, and volume methods), and in vivo NMR spectroscopy (including volume localization techniques). (Prerequisites: Differential and integral calculus, ordinary differential equations; organic chemistry recommended.)

**BME 595. SPECIAL TOPICS IN BIOMEDICAL ENGINEERING.**
Topics in Biomedical Engineering. Presentations and discussions of the current literature in one or more of the following areas: medical imaging, neurosensory systems, bio-statistics.

**BUSINESS, SCHOOL OF ACCOUNTING (ACC)**

**ACC 1100. FINANCIAL ACCOUNTING.** (formerly MG 1100)
Cat. I
This course provides a tool for business communication, as accounting is an important language of business. Students are introduced to the accounting process, its underlying concepts, and the techniques of preparing and analyzing financial statements. Students are also introduced to issues in accounting for assets, liabilities, and stockholders’ equity. The course demonstrates the employment of accounting data by users outside the firm, and the application of accounting numbers in financial analyses and market decisions. Students may not receive credit for both MG 1100 and ACC 1100.

**ACC 2101. MANAGEMENT ACCOUNTING.** (formerly MG 2101)
Cat. I
This course is intended to familiarize the student with the wide variety of ways in which accounting data are used by management as a tool for the attainment of predetermined organizational objectives. The emphasis of the course is on the application of accounting data, rather than on its preparation, and particular attention is given to the use of financial data both in controlling day-to-day activities and planning future operations. Principal topics include: master budgets, cost analysis and classification systems, cost-volume-profit analysis, standard cost accounting and an introduction to capital budgeting. Recommended background: ACC 1100. Students may not receive credit for both MG 2101 and ACC 2101
ACC 4151. COST ACCOUNTING.  
(formerly MG 4151)  
Cat. II  
This course is designed to give basic understanding and skill in the area of cost accumulation to anyone concerned with recording the expenses associated with a given activity or project. Cost accounting provides data for three major purposes: 1) planning and controlling routine operations, 2) making non-routine decisions, and 3) inventory valuation and income determination. All three are important, but the course stresses the first two as they relate to project activity. The goal of the course is to put cost accounting in focus as a highly useful technique in any decision-making situation where expense levels are important. While some attention is directed toward accounting systems and procedures for data accumulation, stress is given to the theme that cost accounting is a vital and dynamic tool for problem-solving.  
Recommended background: ACC 1100.  
Students may not receive credit for both MG 4151 and ACC 4151.  
This course will be offered in 2011-12 and in alternating years thereafter.

BUSINESS (BUS)  

BUS 1010. LEADERSHIP PRACTICE.  
Cat. I  
Leadership is a critical role in any global, technological organization. This course explores how the concepts of creativity, entrepreneurial and critical thinking, emotional and self-awareness, passion, diversity, communication, and ethics inform and affect leadership practice. The course considers a variety of contemporary leadership challenges including how leaders work effectively across cultural, technological, and disciplinary boundaries, how leaders foster new ideas and bring them to fruition, how they communicate effectively and persuasively to diverse stakeholders, and how they make decisions that are both ethical and effective. The course is designed to 1) increase students’ awareness of their own leadership styles, 2) examine the responsibilities of leadership, and 3) determine best practices in leadership.

BUS 1020. GLOBAL ENVIRONMENT OF BUSINESS DECISIONS.  
Cat. I  
The global nature of business is indisputable. This course introduces the students to the complexity of the global environment and adopts a multi-dimensional view (cultural, economic, social, legal, political, and technological) of world economy. It promotes understanding the global environment as integrative forces affecting the success or failure of today’s businesses and fosters a global perspective. Topics may include an overview of the world economy, comparative advantage and international trade, cultural distance, FDI/ globalizaton theory, outsourcing and global supply chain coordination, political and country risk, the global monetary system and currency risk, legal and ethical issues, and risk management.  
Students may not receive credit for both BUS 1020 and BUS 1900.

BUS 1900. INTRODUCTION TO BUSINESS IN AN INTERNATIONAL ENVIRONMENT.  
(formerly MG 1900)  
Cat. I  
This course focuses on the operation of a company conducting business in an international environment. It addresses cultural differences and their importance in international trade and in such business functions as operations, human resources, marketing and accounting. BUS 1900 is an appropriate course for all WPI students regardless of a major.  
Students may receive credit for only one of the following: MG 1050, MG 1900 and BUS 1900.

BUS 2020. THE LEGAL ENVIRONMENT OF BUSINESS DECISIONS.  
Cat. I  
This course addresses the impact of law on business. The course covers fundamental areas of business law, such as torts, contracts, intellectual property, and legal forms of business organizations, and their effects on business decisions. Particular attention is paid to technology-based enterprises where global business issues intersect with law.  
Students may not receive credit for both BUS 2020 and BUS 2950.
ENTREPRENEURSHIP (ETR)

ETR 3633. ENTREPRENEURIAL SELLING.
Cat. I
Selling is a major part of business life, but it is especially important for those who are launching a new venture. They need to sell their business plan to potential investors. Later they need to sell their product or service to a customer. Ultimately they need to create an organization that is focused on meeting customer and other stakeholder needs through effective selling disciplines. This course will examine the elements of the sales cycle in terms of preparation, market research, prospecting, objection handling, closing, techniques for motivating the sales professional and formulation of strategy for the successful selling transaction. As part of the course students will be required to prepare individual sales presentations, one to secure investment for a new venture and one to sell a product or service to a customer. Guest speakers may be used on topics such as sales coaching, inside sales management, and to deliver sales effectiveness training.
Credit may not be earned for both ETR 363X and ETR 3633.

ETR 3910. RECOGNIZING AND EVALUATING NEW VENTURE OPPORTUNITIES.
(formerly MG 3910)
Cat. I
This course focuses on identifying ideas for new businesses and learning how to evaluate those ideas to determine if they are feasible. Using various opportunity recognition models, students will be expected to come up with a business idea and conduct an analysis of the feasibility of the venture and its fit with the founder.
Recommended background for this course consists of OIE 2850 and two of the following: ACC 1100, BUS 2950, OIE 3400, MKT 3600, or MIS 3700.
Students may receive credit for only one of the following: MG 391X, MG 3910 or ETR 3910.

ETR 3920. PLANNING AND LAUNCHING NEW VENTURES.
(formerly MG 3920)
Cat. I
This course focuses on business plan development, especially the financial aspects of the plan. The intent is that students will use a feasibility analysis, such as the one completed in ETR 3910, and turn that into a complete business plan. Additionally, students will learn about seed capital, venture, and other means of financing new ventures.
Recommended background for this course consists of ETR 3910, OIE 2850 and two of the following: ACC 1100, BUS 2950, OIE 3400, MKT 3600, or MIS 3700.
Students may receive credit for only one of the following: ID 1050, MG 3920, or ETR 3920.

ETR 4930. GROWING AND MANAGING NEW VENTURES.
(formerly MG 4930)
Cat. I
One of the most troublesome aspects of entrepreneurship is running the business once it is started. This course focuses on techniques to grow the new venture and how to manage both the growth and operations. Considerable emphasis will be placed on expanding existing markets, finding new markets, anticipating the next generation of products, and managing cash flow. This course is the capstone course for both the Entrepreneurship Minor and the Management Minor.
Recommended background for this course consists of five of the following: ACC 1100, ACC 2101, BUS 1900, BUS 2950, ETR 3910, ETR 3920, MIS 3700, MKT 3600, OBC 2300, OIE 2850, OIE 3400.
Students may receive credit for only one of the following: MG 3960, MG 4930, or ETR 4930.

FINANCE (FIN)

FIN 1250. PERSONAL FINANCE.
(formerly MG 1250)
Cat. I
This course is designed to help the student make well-informed judgments when faced with personal financial decisions. Such decisions are growing in number and complexity, and both individuals and families need a considerable degree of financial expertise in order to utilize optimally their limited incomes. Principal topics include: insurance (medical, life, automobile and disability), consumer credit, estate planning, taxation, personal investments (real estate, securities, etc.), social security legislation and personal financial planning.

FIN 2200. FINANCIAL MANAGEMENT.
(formerly MG 2200)
Cat. I
The financial and competitive status of a company at any given point in time can usually be attributed to prior management decisions. In this course, the student will learn how to use several financial models that together, serve as a sound theoretical framework for analyzing the three types of financial decisions faced by the financial manager. These are 1. investing decisions, 2. financing decisions, and 3. working capital management decisions. The impact of managerial decisions on the financial statements is emphasized. In addition, ethical conduct and global issues relating to the core concepts in the course are explored.
Recommended background: ACC 1100 and MA 2611.
Students may receive credit for only one of the following: MG/IE 2200, MG 2200, or FIN 2200. Students majoring in MG, MGE, or MIS may not receive credit for both FIN 1250 and FIN 2200.

FIN 2250. FINANCIAL SYSTEM OF THE UNITED STATES.
(formerly MG 2250)
Cat. II
An analysis of how the financial system of the United States has developed and contributes to the achievement of broad national economic goals as high national income, satisfactory economic growth, stable prices, and equilibrium in balance of payments with other countries. Emphasis is placed on the theory of the supply and demand for short-term money and long-term capital, and the resultant effect on interest rates. Primary concentration on the sources and uses of funds of the major non-bank financial institutions, such as insurance companies, pension funds, mutual funds, finance companies, savings and loan banks and mutual savings banks. A discussion of the reforms of financial institutions, and of money and capital markets to more efficiently allocate the scarce resources of the country. This course is intended to serve the business major and other students interested in understanding the role of financial intermediaries in the United States economy.
Suggested background: some knowledge of accounting and economics will be helpful in taking this course.
Students may not receive credit for both MG 2250 and FIN 2250.
This course will be offered in 2011-12 and in alternating years thereafter.

FIN 2260. INVESTMENT AND SECURITY ANALYSIS.
(formerly MG 2260)
Cat. I
This course is designed to provide an introduction to the language and methodology of security analysis. It is intended to serve two different groups of students: those interested in the subject from the viewpoint of intelligent management of their own portfolios, and those students who have a possible career interest in some facet of the securities industry. Principal topics include: institutional structure and language of the securities market; investment research; alternative investment opportunities; financial statement analysis; fundamental evaluation of common stocks, preferred stocks and bonds; technical analysis; and business cycle analysis.
Recommended background: ACC 1100 and SS 1120.
Students may not receive credit for both MG 2260 and FIN 2260.

MANAGEMENT INFORMATION SYSTEMS (MIS)

MIS 3700. INFORMATION SYSTEMS MANAGEMENT.
(formerly MG 3700)
Cat. I
This course introduces students to the management of information technology within complex organizations. It covers the range of information technologies employed by business organizations and the manner in which they are deployed. The course places special emphasis on the management of information resources from a user and manager point of view and will help students understand how particular technological arrangements can facilitate achievement of organizational goals. The impact of information technology on management control, organizational structure, individual workers, relationships between organizations, and business transformational will be discussed.
Recommended background: ACC 2101 and OBC 2300 or equivalent business background.
Students may receive credit for only one of the following: MG 2700, MG 3700, or MIS 3700.
MIS 3720. BUSINESS DATA MANAGEMENT. (formerly MG/IE 3720) Cat. I
This course introduces students to the theory and practice of database management and the application of database software to implement business information systems that support managerial and operational decision making. Special topics covered include relational data models, query languages, normalization, locking, concurrency control and recovery. The course covers data administration and the design of data tables for computerized databases. Students will use a commercial database package to design and implement a small business database application.

Recommended background: CS 2118 or equivalent knowledge.
Students may receive credit for only one of the following: MG 4700, MG 3720, or MIS 3720.

MIS 3740. ORGANIZATIONAL APPLICATIONS OF TELECOMMUNICATIONS. (formerly MG 3740) Cat. I
Students taking this course will develop an understanding of how organizations can effectively use telecommunications technology to enhance business functionality. Students will analyze the development of organizational communications infrastructures and their use for the development of “virtual” organizational structures and to support globally-distributed organizations. The course will begin with a survey of the concepts and technologies which form the basis of a business telecommunications system and which allow the merging of voice, data and video in an integrated multimedia communications structures.

Recommended background: MIS 3700.
Students may receive credit for only one of the following: MG 4701, MG 3740, MG/IE 3740, or MIS 3740.

MIS 4720. SYSTEMS ANALYSIS AND DESIGN. (formerly MG/IE 4720) Cat. I
This course integrates students’ background in MIS in a one-term project focusing on development of creative solutions to open-ended business and manufacturing problems. The project will utilize systems analysis and design tools such as systems development life cycle, feasibility study, cost-benefit analysis, structured analysis and design. Students will acquire the skills necessary to analyze, develop, implement, and document real-life information systems. Students must be able to organize themselves and the project to complete their work within a seven week term. It is recommended that MIS majors take this course in preparation for their MQP.

Recommended background: MIS 3720.
Students may receive credit for only one of the following: MG 3750, MG 4720, or MIS 4720.

MIS 4740. E-BUSINESS STRATEGY, ARCHITECTURE AND DESIGN. (formerly MG/IE 4740) Cat. II
The course focuses on the linkage between organizational strategy and networked information technologies to implement a rich variety of business models in the national and global contexts connecting individuals, businesses, governments, and other organizations to each other. It provides an introduction to e-business strategy and the development and architecture of e-business solutions and their technical components. The course will cover how businesses and consumers use the Internet to exchange information and initiate transactions. Both theoretical concepts and practical skills with appropriate development tools will be addressed within the scope of the class. Students will develop a business plan and put that plan into action through development of an e-business website using commercially available development tools.

Recommended background: CS 1101, CS 1102 or CS 2118 or ability to program in a higher level programming language.
This course will be offered 2012-13 and in alternating years thereafter.

MIS 4781. INFORMATION SYSTEMS AND TECHNOLOGY POLICY AND STRATEGY. Cat. III
A successful MIS manager must keep up with the fast-paced changes in technology, apply technology when appropriate, and understand the implications technology has on employees and an organization as a whole. She must understand both the internal (e.g., political and organizational culture) and external (e.g., laws, global concerns, and cultural issues) environments. The core MIS capabilities of business and information technology (IT) vision, design of IT architecture, and IT service delivery also need to be understood by effective MIS managers.

Recommended Background: MIS3700, MIS3720, MIS4720
This course will be offered in 2012-13, and in alternating years thereafter.

MARKETING (MKT)

MKT 3600. MARKETING MANAGEMENT. (formerly MG/IE 3600) Cat. I
This class is designed to give students a broad overview of diverse topics in marketing management. After this class, students should have a solid understanding of the main concepts and principles of marketing, and be able to apply them to actual business situations. The course demonstrates the application of various social science concepts and methodologies in the marketing context. Topics include: The Marketing Environment, International Marketing, Market Research, Consumer Behavior, Business-to-Business Marketing, Services Marketing, Market Segmentation, New Product Development, Channels, Marketing Communications, Personal Selling, and Pricing.

Students may not receive credit for both MG 3600 and MKT 3600.

MKT 3640. MANAGEMENT OF PROCESS AND PRODUCT INNOVATION. (formerly MG/IE 3640) Cat. I
This course is based on the hypothesis that high performance firms depend on a sustainable pattern of new and innovative processes and products. Successful companies are examined in regard to their strategies for innovation and technology transfer. Technology alliances among industry, universities, and government are considered in order to increase the leverage of the individual firm. Licensing and commercialization from research to actualization is discussed through cases and examples.

Recommended background: FIN 2200 or OIE 2850.
Students may receive credit for only one of the following: MG 3440, MG 3640, or MKT 3640.

MKT 3651. INDUSTRIAL MARKETING. (formerly MG/IE 3651) Cat. II
Provides an understanding of the industrial marketing process and practices. It presents the latest concepts, tools and techniques for marketing complex products and services to industrial and institutional users. Topics include: product innovation strategies; purchasing management and buyer behavior; major intelligence; pricing strategies and tactics; developing markets for new industrial products; bid proposals; industrial distribution; managing the industrial sales force; and marketing controls.

Students may not receive credit for both MG 3651 and MKT 3651.
This course will be offered in 2012-13 and in alternating years thereafter.

OPERATIONS AND INDUSTRIAL ENGINEERING (OIE)

OIE 2850. ENGINEERING ECONOMICS. Cat. I
To aid all engineering students in understanding economics and business constraints on engineering decision making. Topics include evaluation of alternatives; the six time-value-of-money factors; present worth, annual cash flow and rate-of-return analysis; incremental analysis; depreciation and income taxes; replacement analysis; inflation; handling probabilistic events; public economy; break-even and minimum cost points; and foreign exchange.

Beginning with the course offerings in the 2009-2010 academic year, students may receive credit for both OIE 2850 and FIN 2200.

OIE 3405. WORK SYSTEMS AND FACILITIES PLANNING. Cat. I
This course covers the fundamentals of developing efficient layouts for production and service facilities. Methods analysis, work measurement, material handling and material flow analysis are also covered. Mathematical models and computer tools are used to assist decision-making.

Recommended background: BUS 2080 and BUS 3020.
OIE 3410. MATERIALS MANAGEMENT IN SUPPLY CHAINS
Cat. I
This course in an introduction to the planning and controlling the material flow into, through, and out of an organization. It explains fundamental relationships among the activities that occur in the supply chain from suppliers to customers. In particular, the course addresses the types of manufacturing systems, demand management and forecasting, master production scheduling, material requirements planning, capacity management, inventory management, distribution resource planning, JIT and lean principles, and other current topics that are pertinent to managing the material flow of supply chains.
Recommended background: knowledge of calculus and BUS 3020.

OIE 3420. QUALITY PLANNING, DESIGN AND CONTROL.
Cat. I
This course provides students with the analytical and management tools necessary to solve manufacturing and service quality problems. Topics include customer needs and quality, quality and cost relationships, process capability analysis, statistical process control, control charts for variables and attributes, design of experiments, and other Six Sigma problem solving methodology.
Recommended background: BUS 3020 and MA 2612 or consent of the instructor.

OIE 3460. SIMULATION MODELING AND ANALYSIS.
Cat. I
This course covers the application of simulation to a variety of managerial problems with examples from operations management, industrial engineering and manufacturing engineering. It introduces the student to the concepts of computer simulation, with an emphasis on the design of a simulation experiment and statistical interpretation of its results. It will discuss simulation of queuing models, inventory and industrial dynamics, and gaming situations. The role and use of computers for the execution of simulations will also be highlighted. A commercial simulation language such as SIMAN will be used to solve problems from the manufacturing and service industries.
Recommended background: BUS 3020 and MA 2612.

OIE 3510. STOCHASTIC MODELS.
Cat. I
This is an introductory course in probabilistic models and decision-making under risk, with applications to engineering and management decision making. The course first covers quantitative methods for assessing and evaluating risks and how they are used in decision making. Decision making under risk is examined across a wide set of management and engineering problems. The course then introduces a set of probabilistic models commonly used in decision making and operations improvement; specifically, emphasis is placed on Markov chains, Poisson processes, and queuing theory, and their applications in manufacturing and service systems are illustrated.
Recommended background: knowledge of calculus and introductory probability and statistics.

OIE 4410. CASE STUDIES IN INDUSTRIAL ENGINEERING.
Cat. I
A number of in-depth case studies in operations and industrial engineering are analyzed. The cases will cover both manufacturing and service systems ranging from production system design to operations planning and control.
Recommended background: BUS 2080, BUS 3020, OIE 3401, and OIE 3501.

OIE 4460. GLOBAL PLANNING AND LOGISTICS.
Cat. II
This case-based course will examine methods and strategies for managing and controlling material movement, with particular emphasis on international operations, from the purchase of production materials to the control of work in process to the distribution of the finished product. Strategies that will be discussed include the design of international distribution networks, the use of third-party logistics providers, and the creation of links between logistic systems and marketing to create competitive advantage. The course will also explore tactical issues that must be managed to pursue a logistics strategy successfully, including choices regarding means of transportation, packaging, and inventory policies. Underlying the success of the course will be the use of information technologies (such as electronic data interchange and bar coding) and mathematical models to support logistics decision-making.
Recommended background: BUS 3020 and either FIN 2200 or OIE 2850 or consent of professor.
This course will be offered 2011-12 and in alternating years thereafter.

ORGANIZATIONAL BEHAVIOR AND CHANGE (OBC)

OBC 2300. ORGANIZATIONAL SCIENCE—FOUNDATION.
(formerly MG/IE 2300)
Cat. I
This first course in organizational science provides the foundation for an understanding of organization and management. It is a survey of the social science of work, describing the basic knowledge and processes required of managers, including: motivation, communication, supervision, leadership, the group processes of decision making, conflict, work and organizational design, and reconciliation of the goals of individuals and organizations. Lecture, video presentation, group discussion and group mini-projects will be employed to introduce and illustrate the basic elements of management.
Students may receive credit for only one of the following: MG 2300, IE 2300, or OBC 2300.

OBC 3351. ORGANIZATIONAL SCIENCE—MANAGEMENT OF CHANGE.
(formerly MG/IE 3351)
Cat. I
This second course in organizational science provides experience in applying theories of organization and management to the analysis and implementation of organizational change. The course utilizes readings, experiential activities, and case studies of change management in technology-based organizations to provide a conceptual understanding as well as practical knowledge of the change management process. The course is designed as a seminar and workshop.
Recommended background: OBC 2300 or consent of the professor. Students may receive credit for only one of the following: MG 3351, IE 3351, or OBC 3351.

OBC 4300. SENIOR SEMINAR.
Cat. I
This course is designed for the senior student who wishes to acquire or strengthen important skills needed for organizational success. Among the subjects covered is power in organizations, what it is, and how to acquire and appropriately use it. Additionally, this course emphasizes presentation skills, organizational etiquette, cross-cultural communication, and the knowledge of current events. The student will be expected to be familiar with and use all forms of media information for both individual and group projects. The course may be counted as a 4000-level elective for MG, MGE, or MIS, or as a Free Elective for any student at WPI.
Recommended Background: Senior standing. Credit may not be earned for both OBC 4300 and OBC 4300.

OBC 4365. LEADERSHIP IN GROUPS AND ORGANIZATIONS.
(formerly MG 4365)
Cat. I
This course considers the essence of leadership in groups and organizations. Specifically, it examines the personal, interpersonal, group, and contextual factors which affect formal and emergent leadership in groups and organizations. It also examines the effectiveness of various leadership approaches and styles under various conditions. Using case studies, simulations, group projects, and selected readings on leadership in groups and organizations, this course will give students an opportunity to assess and develop their own leadership talents.
Recommended background: OBC 2300 or consent of the professor.
Students may not receive credit for both MG 4365 and OBC 4365.

IS4-MANAGEMENT SEMINAR*:
Current developments in management seminars will be organized periodically and announced in the Undergraduate Catalog web site. No more than 1/3 unit credit will be available for this type #4 IS/P.
*Initials of instructors in charge will appear in Undergraduate Catalog web site in addition to a description of seminar to be offered.
CHEMICAL ENGINEERING

NOTE: Courses listed in previous catalogs with “CM” as the prefix and the same course number as below are considered to be the SAME COURSE.

CHE 1011. INTRODUCTION TO CHEMICAL ENGINEERING.
Cat. I
This course provides an introduction to the broad and vital discipline of chemical engineering including conventional and developing chemical technologies. An introduction is provided to the first principles of chemical engineering, as well as environmental, health, safety and ethical issues in chemical engineering practice. An overview is provided of the chemical engineering profession, career choices, the course of study, and a survey of the chemical industry. E.g., polymer, pharmaceutical, food processing, microelectronic, electrochemical, biotechnology, process control, energy, and petroleum refining. Course activities include guest speakers and plant trips.
Recommended for first-year students with a basic knowledge of chemistry.

CHE 2011. CHEMICAL ENGINEERING FUNDAMENTALS.
Cat. I
This first course in chemical engineering is designed to give students the ability to use techniques and solve problems of interest to chemical engineers. Students will learn fundamental material by completing analysis, design, and/or laboratory projects. Topics covered include: material balances and stoichiometry, pressure, volume, and temperature behavior of pure fluids, 1st law of thermodynamics, vapor-liquid equilibria with ideal thermodynamics, and staged separation processes.
Recommended background: Elementary college chemistry and calculus.
Students may not receive credit towards CHE distribution requirements for both CHE 2011 and CM 2001.

CHE 2012. ELEMENTARY CHEMICAL PROCESSES.
Cat. I
This course aims to build a strong foundation in analysis of chemical processes via a project-based approach. Topics covered include analysis and design of stagewise separation processes such as distillation, 1st and 2nd law (of thermodynamics) analysis of power and refrigeration cycles, and application of material and energy balances in industrial chemical processes, including those with recycle and non-ideal systems.
Recommended background: Elementary college chemistry and calculus and some familiarity with the topics listed in CHE 2011.
Students may not receive credit towards CHE distribution requirements for both CHE 2012 and ES 3000.

CHE 2013. APPLIED CHEMICAL ENGINEERING THERMODYNAMICS.
Cat. I
This course uses a project-based approach to build confidence and competence in the use of chemical engineering thermodynamics for the analysis and design of chemical processes. Topics covered include extractive separation systems, solution thermodynamics and nonreacting multicomponent mixtures, phase equilibria and property changes on mixing.
Recommended background: Elementary college chemistry and calculus and some familiarity with the topics listed in CHE 2011 and CHE 2012.
Students may not receive credit towards CHE distribution requirements for both CHE 2013 and CM 2102.

CHE 2014. ADVANCED CHEMICAL PROCESSES.
Cat. I
This course builds on prior work in material and energy balances, chemical engineering thermodynamics, and stagewise separation processes to facilitate student mastery and design of more complex processes. Topics covered include chemical reaction equilibria, material and energy balances for non-steady state systems, combined material and energy balances, humidification, and batch distillation.
Recommended background: Elementary college chemistry and calculus and some familiarity with the topics listed in CHE 2011, CHE 2012, and CHE 2013.
Students may not receive credit towards CHE distribution requirements for both CHE 2014 and CM 2002.

CHE 3201. KINETICS AND REACTOR DESIGN.
Cat. I
Techniques for experimentally determining rate laws for simple and complex chemical reactions, the mechanisms and theories of chemical reactions, the function of catalysts, and the design of isothermal, adiabatic, batch and flow reactors. The course is intended to provide chemists and chemical engineers with the conceptual base needed to study reactions and perform in the design and analysis of reactors.
Recommended background: differential equations, thermodynamics and some organic chemistry.

CHE 3301. INTRODUCTION TO BIOLOGICAL ENGINEERING.
Cat. I
This course is an introduction to the chemical engineering principles involved in modern applications of biological engineering. Topics may include: an introduction to biology, biochemistry, physiology, and genomics; biological process engineering including fermentation, mammalian cell culture, biocatalysis, and downstream bioseparations; drug discovery, development, and delivery; environmental biotechnology; and chemical engineering aspects of biomedical devices.
Recommended background: material and energy balances, thermodynamics, organic chemistry, and differential equations.
This course will be offered in 2011-12, and in alternating years thereafter.

CHE 3302. CHEMICAL AND ENVIRONMENTAL TECHNOLOGY.
Cat. II
This course discusses the sources, sinks, ambient concentrations and effects of major gaseous and particulate air pollutants. The course is problem oriented and applied engineering methods to develop strategies for managing air quality on a local, regional and global scale. Topics include: indoor air quality, regional air shed modelling, global atmospheric change and design and efficiencies of air pollution control devices.
Recommended background: knowledge of chemistry, mathematics and engineering principles.
This course will be offered in 2012-13, and in alternating years thereafter.

CHE 4401. UNI OPERATIONS OF CHEMICAL ENGINEERING I.
Cat. I
Laboratory-application of fundamental theories to practical chemical engineering operations. Emphasis is on building the student’s understanding and ability to approach the problems of design and operations of large scale chemical processing equipment.
The course is a combination of lectures and laboratory projects in the area of unit operations. Laboratory projects include experiments in fluid-flow phenomena through various media such as: friction in conduits, filtration, pressure drop in packed towers, fluidization of solids, and spray drying.
Students are expected to carry out the planning and execution of experimental work as well as the analysis and reporting of experimental results in both written and oral format.

Recommended background: knowledge of chemistry, mathematics and engineering principles.

CHE 4402. UNIT OPERATIONS OF CHEMICAL ENGINEERING II.

Catalog: 1

Overall format and procedure are essentially the same as in Unit Operations of Chemical Engineering I.

Laboratory projects include experiments in heat and mass transfer such as: heat transfer in two heaters and a cooler, climbing film evaporation, multiple effect evaporation, absorption, extraction, distillation and rotary drying of solids.

Recommended background: familiarity with techniques and procedures emphasized in CHE 4401.

CHE 4403. CHEMICAL ENGINEERING DESIGN.

Catalog: 1

Design of equipment, systems and plants; discussion of factors important in chemical plant design such as: economics, cost estimation, profitability, process selection, materials of construction, process control, plant location and safety. Introduction to optimization and computer-aided design. Principles are illustrated with short industrial-type problems.

Recommended background: thermodynamics; heat, mass and momentum transfer; inorganic and organic chemistry; chemical kinetics and reactor design.

CHE 4404. CHEMICAL PLANT DESIGN PROJECT.

Catalog: 1

Application of Chemical Engineering design principles to the design of a major chemical plant. Students work in groups to produce a preliminary practical process flowsheet, equipment and plant design, and economic analysis.

Recommended background: familiarity with techniques and procedures emphasized in CHE 4403.

CHE 4405. CHEMICAL PROCESS DYNAMICS AND CONTROL LABORATORY.

Catalog: 1

This course is intended to provide laboratory application of fundamental principles of chemical process dynamics and feedback control. This includes open-loop dynamics of typical chemical engineering processes such as distillation, fluid flow, chemical reactors and heated stirred tanks. Closed-loop experiments will involve control loop design, controller tuning, multivariable, and computer control.

Students will be required to design and execute their own experiments based on supplied objectives. Analysis and presentation of the results will be done through oral and written reports.

Recommended background: knowledge of fluid flow and heat transfer, mathematics and chemical engineering principles.

Graduate Chemical Engineering Courses of Interest to Undergraduates

CHE 504. MATHEMATICS ANALYSIS IN CHEMICAL ENGINEERING.

Methods of mathematical analysis selected from such topics as vector analysis, matrices, complex variables, Eigenvalue problems, Fourier analysis, Fourier transforms, Laplace transformation, solution of ordinary and partial differential equations, integral equations, calculus of variations, perturbation and asymptotic methods and numerical analysis. Emphasis on application to the solution of chemical engineering problems.

CHE 506. KINETICS AND CATALYSIS.

Theories of reaction kinetics and heterogeneous catalysis are developed for both simple and complex reactions. The kinetics and mechanisms of both catalyzed and uncatalyzed reactions are explored, as well as the effects of bulk and pore diffusion. Techniques for experimentation, reaction data treatment, and catalyst preparation and characterization are related to developing a sound approach to studying a chemical reaction.

CHE 507. CHEMICAL REACTOR DESIGN.

A review of the design of ideal reactors. Main course topics include: deviations from ideal reactor behavior; transport effects in reacting systems; steady state multiplicity and stability analysis; optimization of reactors; analysis of heterogeneous reactors.

CHE 508. CATALYSIS AND SURFACE SCIENCE OF MATERIALS.

The major factors which distinguished catalytic processes for chemicals and fuels from one another are the structure and composition of the materials used as catalysts.

This course examines the detailed structures and reactivities of solid catalysts like zeolites, solid state inorganics, supported metals and metal-support interactions, carbon catalysts, anchored catalysts and others. Several important spectroscopic techniques used in surface science such as X-ray photoelectron spectroscopy (ESCA), electron microprobe, AUGER, scanning electron microscopy, EXAFS, Mossbauer, Fourier-transform infrared, enhanced laser Raman spectroscopy and photoacoustics spectroscopy will be described for characterization of the catalytic surfaces.

The relationship between the structures and reactivities of important catalysts used in hydrocarbon oxidation and functionalization and syngas reactions will be examined to rationalize how they accomplish specific catalytic transformations.

CHE 510. DYNAMICS OF PARTICULATE SYSTEMS.

Systems of discrete particles which grow in size or some other characteristic variable (e.g., age, molecular weight, etc.) are analyzed. Both reaction engineering and population balance analyses are introduced for batch and continuous systems. Steady state and transient system dynamics are explored.

Depending on class interest, specific topics may include: crystallization, latex synthesis, polymer molecular weight distribution, fermentation/ecological systems and gas-solid systems.

CHE 521. BIOCHEMICAL ENGINEERING.

The course emphasizes the basic concepts of biological systems which are relevant to study by chemical engineers. Topics covered include ligand binding and membrane transport processes; growth kinetics of microorganisms; kinetics of interacting multiple populations; biological reactor design and analysis; soluble and immobilized enzyme kinetics; optimization and control of fermentation; and biological product recovery and separation.

CHE 531. FUEL CELL TECHNOLOGY.

The course provides an overview of the various types of fuel cells followed by a detailed discussion of the proton-exchange membrane (PEM) fuel cell fundamentals; thermodynamics relations including cell equilibrium, standard potentials, and Nernst equation; transport and adsorption in proton-exchange membranes and supported liquid electrolytes; transport in gas-diffusion electrodes; kinetics and catalysis of electrocatalytic reactions including kinetics of elementary reactions, the Butler-Volmer equation, reaction routes and mechanisms; kinetics of overall anode and cathode reactions for hydrogen and direct methanol fuel cells; and overall design and performance characteristics of PEM fuel cells.

CHE 554/CH 554. MOLECULAR MODELING.

This course trains students in the area of molecular modeling using a variety of quantum mechanical and force field methods. The approach will be toward practical applications, for researchers who want to answer specific questions about molecular geometry, transition states, reaction paths and photoexcited states. No experience in programming is necessary; however, a background at the introductory level in quantum mechanics is highly desirable. Methods to be explored include density functional theory, ab initio methods, semiempirical molecular orbital theory, and visualization software for the graphical display of molecules.

CHE 561. ADVANCED THERMODYNAMICS.

An examination of the fundamental concepts of classical thermodynamics and presentation of existence theorems for the thermodynamic properties with study of relations among them. The inequality of Clausius as a criterion for equilibrium in both chemical and physical systems. Examination of thermodynamic equilibrium for a variety of restraining conditions. Applications to fluid mechanics, process systems and chemical systems. Computation of complex equilibria.

CHE 571. INTERMEDIATE TRANSPORT PHENOMENA.

Mass, momentum and energy transport; analytic and approximate solutions of the equations of change. Special flow problems such as creeping, potential and laminar boundary-layer flows. Heat and mass transfer in multi-component systems. Estimation of heat and mass transfer rates. Transport with chemical reaction.

CHE 573. SEPARATION PROCESSES.

Thermodynamics of equilibrium separation processes such as distillation, absorption, adsorption and extraction. Multi-staged separations. Principles and processes of some of the less common separations.
CHE 574. FLUID MECHANICS.
Advanced treatment of fluid kinematics and dynamics. Stress and strain rate analysis using vectors and tensors as tools. Incompressible and compressible, one-dimensional flows in channels, ducts and nozzles. Nonviscous and viscous flow fields. Boundary layers and turbulence. Flow through porous media such as fixed and fluidized beds. Two-phase flows with drops, bubbles and/or boiling. Introduction to non-Newtonian flows.

CHE 580. SPECIAL TOPICS.
This course will focus on various topics of current interest related to faculty research experience.

CHEMISTRY AND BIOCHEMISTRY

GENERAL CHEMISTRY SEQUENCE
The general chemistry sequence, CH 1010—1040, is a unified sequence of courses in which areas of major importance in chemistry are discussed in depth from both the empirical and theoretical viewpoints. Each of the four courses develops a theme, or core idea, of chemistry. The sequence is designed for biology, science and engineering majors.

The format of each course includes four 1-hour classroom meetings and one 3-hour laboratory meeting per week. For reasons of safety, contact lenses may not be worn in the chemical laboratories. Prescription glasses meeting the ANSI standard Z87.1 will be accepted as affording adequate eye protection in the laboratory. Otherwise, goggles meeting these standards must be worn at all times.

CH 1010. MOLECULARITY.
Cat. I
The theme of CH 1010 is that all matter in the universe is composed of atoms bonded together in a limited number of ways. Molecularity is one of a small number of fundamental themes of chemistry (and of all science); it is important for us to address it immediately because it permeates all of chemistry.

Specific concepts that we will discuss are:
- Introduction to the Molecular View
- Types of Compounds: The Periodic Table
- Chemical Calculations
- Types of Reactions
- The Quantum Structure of the Atom

CH 1020. FORCES AND BONDING.
Cat. I
We will examine the origin and strength of electrical forces within molecules (covalent bonds), between positive and negative ions in a lattice (ionic bonds), and between atoms or molecules of a pure substance (intermolecular forces). Energy changes accompanying the rupture or formation of such bonds will be discussed.

Specific concepts that we will discuss are:
- Molecular Structure and Shape
- Gases
- Solids
- Intra- and Intermolecular Forces
- Liquids
- Energy (First Law of Thermodynamics)

CH 1030. EQUILIBRIUM.
Cat. I
We will examine the nature of dynamic equilibrium at the molecular level, and will develop an understanding of the mathematical aspects of equilibrium. Phase equilibrium, further aspects of thermodynamics (entropy, free energy), equilibrium of chemical reactions in the gas phase, and equilibrium of chemical reactions in solution will be discussed.

Specific concepts that we will discuss are:
- Phase Equilibrium
- Chemical Equilibrium of Gas Phase Reactions
- Solutions
- Chemical Equilibrium of Reactions in Solution
- Entropy and Free Energy

CHEMISTRY AND BIOCHEMISTRY COURSES

CH 1040. DYNAMICS.
Cat. I
We will examine the nature of molecular motions and their interaction with light, which provides us with all of our structural information about molecules. Various types of molecular spectroscopy will be discussed. Then we will turn to the dynamics of interactions between molecules, examining the rates of chemical reactions, and discussing the detailed molecular pathways by which they occur.

Specific concepts that we will discuss are:
- NMR Spectroscopy
- Vibrational Spectroscopy
- Electronic Spectroscopy
- Dynamics of Physical Processes (Diffusion, phase changes, phase distribution)
- Dynamics of Chemical Processes

ORGANIC CHEMISTRY COURSES

CH 2310. ORGANIC CHEMISTRY I.
Cat. I
A systematic survey of the major reaction types and functional groups in organic chemistry. The course will provide a representative collection of characteristic reactions and transformations of a variety of types of organic molecules. Most of the examples will be drawn from aliphatic chemistry. Some theoretical models will be introduced with a view toward establishing a general overview of the material.

The course is intended for chemists, chemical engineers, pre-medical students and all those interested in the biosciences. A familiarity with the material presented in the general chemistry courses is assumed.

CH 2320. ORGANIC CHEMISTRY II.
Cat. I
Modern theories of aromaticity, including a general assessment of delocalized bonding. The chemistry of some significant functional groups not surveyed in Organic Chemistry I, and the meaning of acidity and basicity in organic chemistry, will be more fully explored. The course will provide an introduction to the systematic synthesis of polyfunctional organic compounds.

Recommended background: CH 2310. The course is intended for chemists, chemical engineers and bio-science majors.

CH 2330. ORGANIC CHEMISTRY III.
Cat. I
This course fully explores three most important analytical methods in organic chemistry: infrared spectroscopy, mass spectrometry, and nuclear magnetic resonance spectroscopy. It will continue the coverage of aromatic chemistry. New topics to be introduced include structures, properties, and reactivities of aldehydes and ketones, carboxylic acids and their derivatives, amines, and the interaction among polyfunctional compounds. It reinforces the retrosynthetic analysis and multistep synthesis of organic compounds and revisits reaction mechanisms and stereochemistry of all the new functional groups studied.

Recommended background: CH 2310 and CH 2320. The course is intended for biochemists, chemists, chemical engineers and bio-science majors.

CH 2360. ORGANIC LABORATORY.
Cat. I
Laboratory experience in the preparation, purification, and characterization of organic substances. The course will also contain sufficient training in laboratory technique and data handling so that no previous laboratory experience beyond that of general chemistry will be assumed. (To be taken concurrently or following studies in organic chemistry.) Recommended for chemical engineers, pre-medical students, BB majors, and other nonchemists desiring chemical laboratory experience. One lecture and three three-hour labs.

CH 3310. ADVANCED ORGANIC CHEMISTRY.
Cat. II
This course will review and further develop concepts introduced in CH2310, CH2320, and CH2330. These concepts will include oxidation states of organic compounds, acidity and basicity, and stereochemistry and conformational analysis. Chemical reactivity will be emphasized and will include functional group interconversion and ionization processes and free radical carbon-carbon bond formation.

Recommended background: CH2310, CH2320, and CH2330. This course is intended for students planning to take advanced courses in organic and/or medicinal chemistry and for chemists, biochemists, chemical engineers, and bio-science majors who desire a stronger background in organic chemistry. Offered in 2012-13 and in alternating years thereafter.
**EXPERIMENTAL CHEMISTRY SEQUENCE**

The following four courses provide a full-year laboratory program. The purpose of this sequence is to train students in the most essential laboratory techniques, procedures, and instrumentation of experimental chemistry. It aims to develop the skills needed for effective work on future chemical laboratory projects such as the Major Qualifying Project. The work of the year develops sequentially.

**CH 2640. EXPERIMENTAL CHEMISTRY I. INSTRUMENTAL ANALYSIS.**

*Cat. I*

This laboratory course focuses on the application of modern instrumental methods of analysis to chemical, biochemical, and environmental problems. Practical experience is gained in quantitative electrochemistry, ultraviolet-visible spectrophotometry, fluorometry and bioluminescence, high performance liquid chromatography, and capillary electrophoresis. Principles of experimental design and execution are developed as student teams select a chemical, biochemical or environmental problem, formulate an approach, conduct the analysis, and present findings to the class. Methods of data analysis and common statistical approaches are emphasized throughout the course.

Recommended background: CH 1010, CH 1020, CH 1030, CH 1040.

**CH 2650. EXPERIMENTAL CHEMISTRY II.**

*Cat. I*

The experiments to be performed this term have been chosen to illustrate important principles and experimental techniques of physical chemistry. Students will gain experience with many of the instruments that they are likely to use in any chemical laboratory setting. These include optical spectrometers, vacuum lines, molecular modeling workstations and calorimeters.

Recommended background: CH 2640 and CH 3510.

**CH 2660. EXPERIMENTAL CHEMISTRY III.**

*Cat. I*

The emphasis in CH 2660 is on basic techniques essential for the synthesis, isolation, and characterization of organic compounds. These include isolation and purification by solvent extraction, crystallization, distillation, and chromatographic techniques, followed by the determination of physical properties and characterization by infrared and nuclear magnetic resonance spectroscopy. Micro-synthetic procedures are introduced. Mastery of the techniques and manipulations emphasized in CH 2640 and CH 2650 would be advantageous.

**CH 2670. EXPERIMENTAL CHEMISTRY IV.**

*Cat. I*

The synthesis, isolation, and characterization of inorganic compounds are emphasized. Syntheses of main group compounds, classical transition metal complexes, and organotransition metal compounds are included. In addition to reinforcing and building on standard techniques of synthesis and characterization, several new techniques are introduced: synthesis under inert atmosphere, measurement of magnetic susceptibility by NMR, and cyclic voltammetry. Some exposure to 13C NMR is also provided. The final experiment of the course requires the student to design a synthesis for a compound selected from a list provided, based on strategies learned in the course.

**INORGANIC AND PHYSICAL CHEMISTRY COURSES**

**CH 3410. PRINCIPLES OF INORGANIC CHEMISTRY.**

*Cat. I*

This course provides the fundamental understanding of atomic, molecular and solid state structures and properties. Orbital structures of atoms, symmetry of molecules and point groups are used to understand chemical bonding and reactions. Various acid-base concepts are explored to analyze the acidity of cations and basicity of anions, solubility and precipitations of inorganic compounds, and metal-ligand binding affinities. Redox properties are discussed using Pourbaix diagrams. Thermodynamic stabilities of inorganic species are discussed using acid-base and redox concepts and thermochemical analyses are used to analyze chemical reactivity at atomic, molecular, and solid state level.

**CH 3510. CHEMICAL THERMODYNAMICS.**

*Cat. I*

The content of this course will be the development of the principles of classical thermodynamics. The laws of thermodynamics will be developed by using a series of increasingly complex model systems and a universal equation of state is formulated which incorporates the relationships illustrated by these model systems. Using this equation it will be possible to appreciate that thermody-

**BIOCHEMISTRY COURSES**

**CH 4110. BIOCHEMISTRY I.**

*Cat. I*

The principles of protein structure are presented. Mechanisms of enzymatic catalysis, including those requiring coenzymes, are outlined in detail. The structures and biochemical properties of carbohydrates are reviewed. Bioenergetics, the role of ATP, and its production through glycolysis and the TCA cycle are fully considered.

Recommended background: CH 2310, CH 2320.

**CH 4120. BIOCHEMISTRY II.**

*Cat. I*

Oriented around biological membranes, this course begins with a discussion of electron transport and the aerobic production of ATP followed by a study of photosynthesis. The study of the biosynthesis of lipids and steroids leads to a discussion of the structure and function of biological membranes. Finally the membrane processes in neurotransmission are discussed.

Recommended background: CH 4110.

**CH 4130. BIOCHEMISTRY III.**

*Cat. I*

This course presents a thorough analysis of the biosynthesis of DNA (replication), RNA (transcription), and proteins (translation). Proteins and RNAs have distinct lifetimes within the living cell; thus the destruction of these molecules is an important biochemical process that is also discussed. In addition to mechanistic studies, regulation of these processes is covered.

Students who have received credit for CH 4130 or BB 4910 prior to Term A 2000 may not receive credit for the other course.

**CH 4150. EXPERIMENTAL BIOCHEMISTRY.**

*Cat. I*

The experiments in this laboratory course have been designed to acquaint the students with the basic skills necessary to perform biochemical studies. The course will cover, for instance, protein purification, subcellular fractionation, enzyme kinetics (Km, Vmax, specific activity, effector-protein interaction, etc.), exclusion and ion exchange chromatography, and electrophoresis.

Recommended background: CH 4120.
CH 4160. MEMBRANE BIOPHYSICS.
Cat. II
This course will focus on different areas of biophysics with special emphasis on membrane phenomena. The biomedical-biological importance of biophysical phenomena will be stressed. The course will begin with the introduction of the molecular forces relevant in biological media and subsequently develop the following topics: Membrane Structure and Function; Channels, Carriers and Pumps; Nerve Excitation and related topics; and Molecular Biophysics of Moiety.
Recommended background: prior knowledge of Biochemistry (CH 4110, CH 4120), Mechanics (PH 1110) and Electricity (PH 1120).
This course will be offered in 2011-12 and in alternating years thereafter.

CH 4170. EXPERIMENTAL BIOCHEMISTRY II.
Cat. I
This laboratory course focuses on modern DNA technologies and general applications of gene manipulation. Topics include gene amplification and recombination, promoter and plasmid engineering, gene expression and analysis, model systems, genomics and transgenics: Experiments in this course are integrated into an overall generic engineering project throughout the term that will involve techniques such as electrophoresis, quantitative spectrophotometry, and real-time quantitative PCR. Methods of data analysis, common statistical approaches and technical writing will be emphasized throughout the course.
Recommended background: CH 4110, CH 4120, CH 4130.

CH/BB 4190. REGULATION OF GENE EXPRESSION.
Cat. I
This course will cover the biochemical mechanisms involved in regulation of gene expression, modifications of DNA structures that influence transcription rates, transcriptional regulation by protein binding, post-transcriptional modifications of RNA including splicing and editing, regulation of translation including ribosome binding and initiation of translation, and factors that control the half-lives of both mRNA and protein. During the course, common experimental methods will be explored, including a discussion of the information available from each method.
Recommended background CH 4110, CH 4120, CH 4130, BB 4010

ADVANCED CHEMISTRY COURSES

CH 4330. ORGANIC SYNTHESIS.
Cat. II
A discussion of selected modern synthetic methods including additions, condensations and cyclizations. Emphasis is placed on the logic and strategy of organic synthesis. This course is intended to follow CH 2330.
Recommended background: CH 2310, CH 2320, and CH 2330.
This course will be offered in 2012-13 and in alternating years thereafter.

CH 4420. INORGANIC CHEMISTRY II.
Cat. II
Complexes of the transition metals are discussed. Covered are the electronic structures of transition metal atoms and ions, and the topological and electronic structures of their complexes. Symmetry concepts are developed early in the course and used throughout to simplify treatments of electronic structure. The molecular orbital approach to bonding is emphasized. The pivotal area of organotransition metal chemistry is introduced, with focus on complexes of carbon monoxide, metal-metal interactions in clusters, and catalysis by metal complexes.
Recommended background: CH 1010 - CH 1040, CH 2640 - CH 2670, CH 3410, CH 3530, and CH 3550.
This course will be offered in 2011-12 and in alternating years thereafter.

CH 4530. CHEMICAL STATISTICAL MECHANICS.
Cat. II
This course deals with how the electronic, translational, rotational and vibrational energy levels of individual molecules, or of macromolecular systems, are statistically related to the energy, entropy, and free energy of macroscopic systems, taking into account the quantum mechanical properties of the component particles. Ensembles, partition functions, and Boltzmann, Fermi-Dirac, and Bose-Einstein statistics are used. A wealth of physical chemical phenomena, including material related to solids, liquids, gases, spectroscopy and chemical reactions are made understandable by the concepts learned in this course.
Recommended background: CH 3510 and CH 3530, or equivalent, and mathematics through differential and integral calculus.
This course will be offered in 2011-12 and in alternating years thereafter.

CIVIL AND ENVIRONMENTAL ENGINEERING

CE 1030. CIVIL ENGINEERING AND COMPUTER FUNDAMENTALS.
Cat. I
This course introduces students to basic fundamentals of civil engineering, group dynamics, oral presentation skills, engineering report writing techniques, and uses of the computer. Basics of structural engineering, geotechnical engineering, environmental engineering, surveying, materials, and construction engineering and management are presented in this course through a collaborative group teaching approach. Background is provided to gain competence in operating systems, editors, and spreadsheets. Student groups complete weekly computer laboratory projects and develop oral presentations and written reports.
No previous computer use skills are required or assumed. This course is recommended for freshman or sophomore students.

CE 2000. ANALYTICAL MECHANICS I.
Cat. I
This fundamental civil engineering course provides an introduction to the analysis of structures in static equilibrium. The focus of this course is a classical analysis of concurrent and non-concurrent equilibrium. A variety of engineering problems including trusses, machines, beams, rigid frames, and hydraulic structures involving concentrated and distributed loading systems are analyzed for external reactions and internal forces.
CE 2001. ANALYTICAL MECHANICS II.
Cat. I
This course provides an introduction to the relationship between analysis, design, and the behavior of materials under load. Theory and applications are developed that utilize simple and combined stress-strain behavior of members subjected to axial, torsional, and flexural loadings, with applications to beams, trusses, rigid frames, shafts, and tension and compression structures.
Recommended background: CE 2000.

CE 2002. INTRODUCTION TO ANALYSIS AND DESIGN.
Cat. I
This course develops an understanding of classical and modern structural analysis. Topics include loading systems, and the analysis of statically determinate and statically indeterminate beams, frames, trusses, structural floor systems for buildings, bridges, and other structural assemblies.
Suggested background: CE 1030.

CE 2020. SURVEYING.
Cat. I
This course develops fundamental skills in the theoretical and practical aspects of plane surveying through the use and care of modern instruments and the associated computations. Topics include the classification of errors incurred in observed field data and necessary correction applications, the use and care of surveying equipment, traversing, differential leveling, stadia and mapping, and electronic data transfer. Computer applications are used where appropriate.

CE 3006. DESIGN OF STEEL STRUCTURES.
Cat. I
This course covers the theory and practice of structural steel design. The structural design process for beams, columns, trusses, frames, and connections is based on Load and Resistance Factor Design (LRFD) specifications of the American Institute of Steel Construction.
Recommended background: CE 2002 and CE 3010.
Suggested background: CE 1030.

CE 3008. DESIGN OF REINFORCED CONCRETE STRUCTURES.
Cat. I
This course covers the theory and practice of reinforced concrete design. The structural design process for beams, columns, slabs, frames, flat slabs, footings, and retaining walls uses the ultimate strength design codes of the American Concrete Institute.
Recommended background: CE 2002 and CE 3010.
Suggested background: CE 1030.

CE 3010. STRUCTURAL ENGINEERING.
Cat. I
This course provides an understanding of the practice of structural engineering. It builds upon the fundamental skills developed in CE 2000, CE 2001, and CE 2002 to present the principles of structures and their elements. The course provides a perspective for dealing with the issues of strength, stiffness, and stability. Although wood is the principle material used to develop the study of the interrelationship between analysis and design of structural systems, structural steel and reinforced concrete systems are also discussed. It also introduces students to the use of building codes for design criteria. The role of the structural engineer in the design process and cost factors are also discussed.
Suggested background: CE 1030.

CE 3020. PROJECT MANAGEMENT.
Cat. I
This course presents the fundamental concepts and process of project management applied to public and private works. The principle focus of the course is the management of civil engineering projects including planning, scheduling, organization and control, as well as management concepts of leadership, motivation, trust, project team development, division of work, and conflict resolution. Ancillary engineering and construction practices involving financial practices, construction documents, contract negotiation and administration, quality and safety control, insurance and bonding are covered.
Recommended background: CE 1030.

CE 3021. COST ESTIMATING, SCHEDULING AND PROJECT CONTROL.
Cat. II
This course presents the fundamental concepts and processes by which the cost and time of execution of civil engineering projects are established. It emphasizes the importance of decisions made at the early stages of design on final project cost. The relationship between time and cost is examined in detail. Topics include: construction methods, quantity surveying, resource pricing, activity planning, resource allocation, financial analysis, bidding, job cost accounting and cost control with extensions to operating and maintenance costs. Commercial software for project scheduling, cost estimating, and cost control is used in this course.
Recommended background: CE 1030 and CE 3020.
Offered in 2012-13 and in alternating years thereafter.

CE 3022. LEGAL ASPECTS IN DESIGN AND CONSTRUCTION.
Cat. II
This course addresses legal aspects that underpin the planning, design and construction of a project. The principle focus is the contracts, laws, specifications, and design documents needed to conduct civil engineering practice in the United States. Labor, safety, and environmental laws are reviewed, as well as the role of equity and professional relationships with the client, other professional organizations and groups, the public, and the regulatory system.
Recommended background: CE 3020.
Offered in 2011-12 and in alternating years thereafter.

CE 3023. ARCHITECTURAL ENGINEERING SYSTEMS.
Cat. I
This course introduces the fundamental concepts associated with the design and construction of a building. Major building components, such as foundations, structures, envelopes and environmental systems are presented as subsystems to be integrated. The systems approach is utilized to describe the functional interdependence of building components and the interdisciplinary nature of the design of contemporary buildings. Building components are analyzed in terms of design details and constructability implications. Graphic representation and building design exercises as well as case studies are used to illustrate the topic.

CE 3024. CONTROL SURVEYING.
Cat. II
This course presents the principles and field procedures required in the design of vertical and horizontal control networks for large building and construction projects.
Recommended background: CE 2020.
Offered in 2012-13 and in alternating years thereafter.

CE 3026. MATERIALS OF CONSTRUCTION.
Cat. I
This course provides an understanding of the use and acquisition of engineering properties of construction materials. Topics include relationships between the structure of materials, their engineering properties, and the selection of suitable materials for applications involving strength, durability, and serviceability. Experimental laboratory procedures including design of experiments, data collection, analysis, and representation, and report writing are an integral part of the work.
Recommended background: CE 1030 and CE 2001.

CE 3030. FUNDAMENTALS OF CIVIL ENGINEERING AUTOCAD.
Cat. I
This course introduces Civil Engineering students to fundamental uses of the AutoCAD software package. Basic two dimensional drawing techniques are covered. Advanced topics that may be covered include three dimensional drafting, rendering and animation. Students are required to become familiar with AutoCAD.
Knowledge of the subject matter in at least two civil engineering design courses is expected background for this course.

CE 3031. 3D OBJECT-ORIENTED PARAMETRIC SOFTWARE APPLICATIONS IN CIVIL ENGINEERING.
Cat. I
This course introduces students to fundamental software applications for design and construction planning throughout the different phases of the development of civil engineering projects. The course covers the principles of basic 3D software environments, object creation and manipulation, assemblies of objects, surface and terrain modeling, building modeling, geographic and building information databases. Emphasis is given to the adaptability of this software to
Changes in design and the production of graphic design documentation. Application software such as AutoCAD Civil 3D and Autodesk Revit is used in this course.

**Recommended background:** CE 1030.

**CE 3041. SOIL MECHANICS.**

*Cat. I*

This is an introductory course dealing with the science and technology of earth materials with an emphasis on fundamental concepts of particulate mechanics. The topics which are discussed include fluid flow through porous media, deformation and shear characteristics of soil, consolidation, lateral earth pressure, and slope stability.

**Recommended background:** CE 2000 and CE 2001.

**Suggested background:** GE 2341.

**CE 3044. FOUNDATION ENGINEERING.**

*Cat. II*

Foundation engineering is a study of the applications of the principles of soil mechanics and structural theory to the analysis, design and construction of foundations for engineering works with the emphasis on the soil engineering aspects of soil structure interaction. Subsurface exploration techniques, design of rigid and flexible retaining structures, and design of, shallow and deep foundations are considered. Although the course deals mainly with aspects of the design of buildings and bridges, certain parts of the course (design of temporary trench bracing, for example) are very relevant to construction engineering.

**Recommended background:** CE 3041.

**Suggested background:** CE 3008.

**Offered in 2012-13 and in alternating years thereafter.**

**CE 3050. TRANSPORTATION: TRAFFIC ENGINEERING.**

*Cat. I*

This course provides an introduction to the field of transportation engineering with particular emphasis on traffic engineering. Topics covered include a description of the transportation industry and transportation modes; characteristics of drivers, pedestrians, vehicles and the roadway; traffic engineering studies, highway safety, principles of traffic flow, intersection design and control, capacity analysis, and level of service analysis.

**Suggested background:** CE 2020.

**CE 3051. TRANSPORTATION: PAVEMENT ENGINEERING.**

*Cat. I*

This course provides an introduction to concepts required for design construction and management of pavements. Topics include Highway Drainage, Soil Engineering for Highway Design, Bituminous Materials, Design of Flexible and Rigid Pavements and Pavement Management. Knowledge of the subject matter in CE 3050 is helpful but not required.

**CE 3059. ENVIRONMENTAL ENGINEERING**

*Cat. I*

This course provides an introduction to engineering aspects of environmental quality control. Students will learn fundamental science and engineering principles needed for environmental engineering, including concepts in chemistry, biology, physics, mass conservation, kinetics and reactor design. These principles are then applied to environmental engineering problems, including modeling of pollutants in natural systems and design of unit processes in engineered systems. Topics covered include environmental regulations, surface and ground water quality, drinking water treatment, wastewater treatment, air pollution, and hazardous waste management.

**Recommended background:** college-level chemistry.

**CE 3060. WATER TREATMENT.**

*Cat. I*

This course provides in-depth coverage of processes used in water treatment. Topics include: review of water chemistry and drinking water standards, impurities in natural waters, aeration, water softening coagulation, flocculation, sedimentation, filtration, disinfection, taste and odor control, corrosion control, and iron and manganese removal.

**Recommended background:** CE 3059 and ES 3004.

**CE 3061. WASTE WATER TREATMENT.**

*Cat. I*

This course provides in-depth coverage of processes used in wastewater treatment. Topics include: review of water quality standards, wastewater characteristics, application of biochemical oxygen demand, sources and effects of pollution, physical, chemical, and biological wastewater treatment processes, and waste sludge management.

**Recommended background:** CE 3059 and ES 3004.

**CE 3062. HYDRAULICS.**

*Cat. I*

This course provides a background for applying the principles of fluid mechanics to analyze and design hydraulic and fluid flow systems for projects related to water resources and civil and environmental engineering. Topics include hydraulics in pipes and closed systems, open channels and rivers, water supply systems and water distribution networks, pump systems and turbines, wastewater collection and treatment systems, and coastal and other natural environmental systems. Course content includes water quality and energy considerations, as well as the development and application of hydraulic models.

**Recommended background:** ES 3004.

**CE 3070. URBAN AND ENVIRONMENTAL PLANNING.**

*Cat. I*

This course introduces to the student the social, economic, political, and environmental factors that affect the complex relationship between the built and natural environment. By using the principles of sustainable development and the procedures of planning, the optimal development pattern may be examined, and the infrastructure (roads, water supply systems, waste-water treatment systems, shopping malls, etc.) necessary to support present and future growth patterns may be determined. The information necessary in planning, which involves conscious procedures of analysis, formulation of alternative solutions, rational assessment and deliberate choice in accordance with evaluation criteria, is obtained through extensive reading. As such, the course introduces a variety of topics of concern to engineers and environmental scientists. The course is intended not only for civil engineering majors, but also for students preparing for an EQP in areas of urban or environmental concerns.

**CE 3074. ENVIRONMENTAL ANALYSIS.**

*Cat. II*

This course provides a background in the principles and techniques of assessing areas of natural environment and applying environmental assessments to evaluate the inherent suitability of these areas for sustainable urban and resource-based uses. Topic areas include basic concepts in sustainability, landscape characterization and analysis, and environmental impact assessment and planning. The concepts and techniques developed in this course are useful for land use planning, site design, natural resources management, and the determination of the impact of engineering projects on the environment.

**Suggested background:** CE 3059 or CE 3070.

**Offered in 2011-12 and in alternating years thereafter.**

**CE 4007. MATRIX ANALYSIS OF STRUCTURES.**

*Cat. II*

This course presents the principles of matrix analysis of structural elements and systems: fundamentals of matrix algebra, solution of simultaneous equations, matrix inversion; analysis of plane trusses, method of joints; displacement method, principle of virtual work, analysis of continuous beams, analysis of plane frames, plane trusses, analysis of building frames and bridges; computer aided structural analysis and principles of software development.

**Recommended background:** CE 2002.

**Offered in 2012-13 and in alternating years thereafter.**

**CE 4017. PRESTRESSED CONCRETE DESIGN.**

*Cat. II*

This course covers analysis and design aspects of prestressed concrete structural elements and systems: principles of prestressing, materials for prestressing, high strength steel, flexural analysis and design methods; allowable stress and strength design methods; design of beams, load balancing, partial prestressing and cracking moment; design for shear, partial loss of prestress; deflections of prestressed concrete and precast construction; connections.

**Recommended background:** CE 2002 and CE 3026.

**Suggested background:** CE 3008.

**Offered in 2011-12 and in alternating years thereafter.**
CE 4046. EXPERIMENTAL SOIL MECHANICS.
Cat. II
The standard laboratory soil testing procedures generally encountered in civil engineering are introduced in this course. It further includes a limited discussion of soil behavior primarily based on the effect of soil's physical and chemical properties on laboratory test results. The tests which are performed include: grain size analysis, Atterberg limits, specific gravity, permeability, compaction, compression and consolidation, and direct and triaxial shear. The student's results of the various tests are integrated within an engineering problem.
Recommended background: CE 3041.
Offered in 2011-12 and in alternating years thereafter.

CE 4054. TRANSPORTATION: INFRASTRUCTURE MATERIALS LABORATORY.
Cat. II
This laboratory-based course introduces standard laboratory soil and asphalt materials testing procedures, and effect of physical properties on performance of soils and asphalt pavements. The tests which are performed include: grain size analysis, Atterberg limits, specific gravity, permeability, compaction, compression and consolidation, and triaxial shear for soils, and penetration, consensus and source properties of aggregate, compaction, resilient modulus, indirect tensile strength and nondestructive testing of soils and hot mix asphalt. Instruction is provided through lecture, laboratory work and field trip.
Recommended background: CE 3041 and CE 3052.
Offered in 2011-12 and in alternating years thereafter.

CE 4060. ENVIRONMENTAL ENGINEERING LABORATORY.
Cat. I
This course familiarizes students with the laboratory studies used to obtain the design parameters for water and wastewater treatment systems. The topics include laboratory experiments dealing with physical, chemical, and biological treatment systems.
Recommended background: CE 3060 and CE 3061.

CE 4061. HYDROLOGY.
Cat. II
This course introduces the concepts and principles governing the distribution and transport of water in the environment, and also provides a background for quantifying hydrologic processes as required for the development of water resources projects. Topics include the hydrologic cycle, precipitation, evaporation and transpiration, infiltration, runoff analysis, streamflow, hydrologic routing, statistics and probability in hydrology, and the quantification of hydrologic processes for water quality protection. The course introduces field techniques and the use of hydrologic models for solving problems in water resources and hydrology.
Recommended background: ES 3004.
Offered in 2011-12 and in alternating years thereafter.

CE 4071. LAND USE DEVELOPMENT AND CONTROLS
Cat. I
The purpose of this course is to provide an understanding of the regulatory framework under which land is developed and the built environment is designed. The quality of our environment depends upon the development which is permitted to take place and the controls which direct that development. Through this course, the student will learn the principles, methods, and techniques which a planner or engineer may use to plan and design the highest and best uses and development of land. In particular, the use and limits of zoning, special permits, subdivision control, and other tools with which a developer or planner should be familiar will be examined in detail.

CE 4060. HAZARDOUS AND INDUSTRIAL WASTE MANAGEMENT.
Cat. II
This course will cover concepts and techniques for handling hazardous and industrial wastes. Regulations governing hazardous waste, water & soil remediation concepts, and the fundamentals of waste treatment processes will be discussed. Instruction will be provided through lectures, fieldtrips, practitioner seminars, and class problem solving sessions.
Recommended background: ES 3004 and CE 3059.
This course will be offered in 2012-13 and in alternating years thereafter.

CS 1101. INTRODUCTION TO PROGRAM DESIGN.
Cat. I
This course introduces principles of computation and programming with an emphasis on program design. Topics include design and implementation of programs that use a variety of data structures (such as records, lists, and trees), functions, conditional, and recursion. Students will be expected to design, implement, and debug programs in a functional programming language.
Recommended background: none. Either CS 1101 or CS 1102 provide sufficient background for further courses in the CS department. Undergraduate credit may not be earned for both this course and CS 1102. Undergraduate credit may not be earned both for this course and for CS 2135.

CS 1102. ACCELERATED INTRODUCTION TO PROGRAM DESIGN.
Cat. I
This course provides an accelerated introduction to design and implementation of functional programs. The course presents the material from CS 1101 at a fast pace (so students can migrate their programming experience to functional languages), then covers several advanced topics in functional programming (potential topics include macros, lazy programming with streams, and programming with higher-order functions). Students will be expected to design, implement, and debug programs in a functional programming language.
Recommended background: prior programming background covering lists, trees, functions, and recursion.
Undergraduate credit may not be earned for both this course and CS 1101. Undergraduate credit may not be earned both for this course and for CS 2135.

CS 2011. INTRODUCTION TO MACHINE ORGANIZATION AND ASSEMBLY LANGUAGE.
Cat. I
This course introduces students to the structure and behavior of digital computers at several levels of abstraction. Using a bottom-up approach, the course starts by examining logic gates and digital circuits. The student is then introduced to virtual machines at successively higher levels of abstraction, beginning with the Von Neumann model of execution, and progressing through machine language, assembly language, and high-level languages. Topics include the functional organization of computer hardware, the functions of assemblers, linkers, and loaders, representations of numbers in computers, basic assembly language instruction sets, addressing modes, stacks and procedures, low-level I/O, concepts and examples of microprogramming, and logic circuits.
Students will be expected to design, implement, and debug programs in an assembly language.
Recommended background: CS 2303 or CS 2301.

CS 2022/MA 2201. DISCRETE MATHEMATICS.
Cat. I
This course serves as an introduction to some of the more important concepts, techniques, and structures of discrete mathematics, providing a bridge between computer science and mathematics.
Topics include functions and relations, sets, countability, groups, graphs, propositional and predicate calculus, and permutations and combinations.
Students will be expected to develop simple proofs for problems drawn primarily from computer science and applied mathematics.
Undergraduate credit may not be earned both for this course and for CS 501.
Recommended background: none.

CS 2102. OBJECT-ORIENTED DESIGN CONCEPTS.
Cat. I
This course introduces students to an object-oriented model of programming. Building from the design methodology covered in CS 1101/CS 1102, this course shows how programs can be decomposed into classes and objects. By emphasizing design, this course shows how to implement small defect-free programs and evaluate design decisions to select an optimal design under specific assumptions. Topics include inheritance, exceptions, interface, design by contract, basic design patterns, and reuse. Students will be expected to design, implement, and debug object-oriented programs composed of multiple classes and over a variety of data structures.
CS 2118. OBJECT-ORIENTED DESIGN CONCEPTS FOR BUSINESS APPLICATIONS.

Cat. I
This course introduces students to an object-oriented model of programming, with an emphasis on the programming approaches useful in creating business applications. Building from the design methodology covered in CS 1101/CS 1102, this course shows how programs can be decomposed into classes and objects. Students will be expected to design, implement, and debug object-oriented programs in Visual Basic. Topics include inheritance, building user interfaces, and database access. This course is primarily for CS majors with prior programming experience and an interest in building business applications.

Recommended background: CS 1101 or CS 1102.
Students may receive credit for only one of the following: MG 2720, MIS 2720, CS 2136, or CS 2118.

CS 2223. ALGORITHMS.

Cat. I
Building on a fundamental knowledge of data structures, data abstraction techniques, and mathematical tools, a number of examples of algorithm design and analysis, worst case and average case, will be developed.

Topics include greedy algorithms, divide-and-conquer, dynamic programming, heuristics, and probabilistic algorithms. Problems will be drawn from areas such as sorting, graph theory, and string processing. The influence of the computational model on algorithm design will be discussed.

Students will be expected to perform analysis on a variety of algorithms.
Undergraduate credit may not be earned both for this course and for CS 507.
Recommended background: CS 2102 and CS 2022.

CS 2301. SYSTEMS PROGRAMMING FOR NON-MAJORS.

Cat. I
This course introduces the C programming language and system programming concepts to non-CS majors who need to program computers in their own fields. The course assumes that students have had previous programming experience. It quickly introduces the major concepts of the C language and covers manual memory management, pointers and basic data structures, the machine stack, and input/output mechanisms. Students will be expected to design, implement, and debug programs in C.

Recommended background: CS 1101 or CS 1102 or previous experience programming a computer. All Computer Science students and other students wishing to prepare for upper-level courses in Computer Science should take CS 2303 instead of CS 2301. Students who have credit for CS 2303 may not receive subsequent credit for CS 2301.

CS 2303. SYSTEMS PROGRAMMING CONCEPTS.

Cat. I
This course introduces students to a model of programming where the programming language exposes details of how the hardware stores and executes software. Building from the design concepts covered in CS 2102, this course covers manual memory management, pointers, the machine stack, and input/output mechanisms. The course will involve large-scale programming exercises and will be designed to help students confront issues of safe programming with system-level constructs. The course will cover several tools that assist programmers in these tasks. Students will be expected to design, implement, and debug programs in C++, C, and C. The course presents the material from CS 2301 at a fast pace and also includes C++, C, and other advanced topics.

Recommended background: CS 2102 and/or substantial object-oriented programming experience.

CS 3013. OPERATING SYSTEMS.

Cat. I
This course provides the student with an understanding of the basic components of a general-purpose operating system. Topics include processes, process management, synchronization, input/output devices and their programming, interrupts, memory management, resource allocation, and an introduction to file systems. Students will be expected to design and implement a large piece of system software in the C programming language.
Undergraduate credit may not be earned both for this course and for CS 502.
Recommended background: CS 2303 or CS 2301, and CS 2111.

CS 3041. HUMAN-COMPUTER INTERACTION.

Cat. I
This course develops in the student an understanding of the nature and importance of problems concerning the efficiency and effectiveness of human interaction with computer-based systems.
Topics include the design and evaluation of interactive computer systems, basic psychological considerations of interaction, interactive language design, interactive hardware design, and special input/output techniques.
Students will be expected to complete several projects. A project might be a software evaluation, interface development, or an experiment.
Recommended background: CS 2102 or CS 2118.

CS 3043. SOCIAL IMPLICATIONS OF INFORMATION PROCESSING.

Cat. I
This course makes the student aware of the social, moral, ethical, and philosophical impact of computers and computer-based systems on society, both now and in the future.
Topics include major computer-based applications and their impact, human-machine relationships, and the major problems of controlling the use of computers.
Students will be expected to contribute to classroom discussions and to complete a number of significant writing assignments.
This course is recommended for juniors and seniors.
Undergraduate credit may not be earned both for this course and for CS 505.
Recommended background: a general knowledge of computers and computer systems.

CS 3133. FOUNDATIONS OF COMPUTER SCIENCE.

Cat. I
This course introduces the student to the design, use, and application of database management systems.
Topics include the relational data model, relational query languages, design theory, and conceptual data design and modeling for relational database design. Techniques that provide for data independence, and minimal redundancy will be discussed.
Students will be expected to design and implement database system applications.
Undergraduate credit may not be earned both for this course and for CS 504.
Recommended Background: CS 2022 and CS 2223.
Students who have credit for CS 4121 cannot receive credit for CS 3133.

CS 3431. DATABASE SYSTEMS I.

Cat. I
This course introduces the student to the design, use, and application of database management systems.
Topics include the relational data model, relational query languages, design theory, and conceptual data design and modeling for relational database design. Techniques that provide for data independence, and minimal redundancy will be discussed.
Students will be expected to design and implement database system applications.
Undergraduate credit may not be earned both for this course and for CS 4431 or CS 542.
Recommended background: CS 2022 and either CS 2102 or CS 2118.

CS 3516. COMPUTER NETWORKS.

Cat. I
This course provides a broad view of computer networks. The course exposes students to all seven layers of OSI Reference Model while providing an introduction into newer topics such as wireless networking and Internet traffic concerns. The objective is to focus on an understanding of fundamental concepts of modern computer network architecture from a design and performance perspective. Topics covered include: physical layer considerations, network protocols, wide area networks, local area networks, wireless networks, switches and routing, congestion, Internet traffic and network security. Students will be expected to do systems/network programming and make use of simulation and measurement tools to gain an appreciation of current network design and performance issues. This course is also highly recommended for RBE and IMGD majors.
Recommended background: CS 2303 or CS 2301.

CS 3733. SOFTWARE ENGINEERING.

Cat. I
This course introduces the fundamental principles of software engineering. Modern software development techniques and life cycles are emphasized.
Topics include requirements analysis and specification, analysis and design, architecture, implementation, testing and quality, configuration management, and project management.
Students will be expected to complete a project that employs techniques from the topics studied.

This course should be taken before any course requiring a large programming project.

Undergraduate credit may not be earned both for this course and for CS 509.

Recommended background: CS 2102.

CS 4032/MA 3257. NUMERICAL METHODS FOR LINEAR AND NONLINEAR SYSTEMS.

Cat. I

This course provides an introduction to modern computational methods for linear and nonlinear equations and systems and their applications.

Topics covered include: solution of nonlinear scalar equations, direct and iterative algorithms for the solution of systems of linear equations, solution of nonlinear systems, the eigenvalue problem for matrices. Error analysis will be emphasized throughout.

Recommended background: MA 2051. An ability to write computer programs in a scientific language is assumed. Undergraduate credit may not be earned for both this course and for MA 3255/CS 4031.

CS 4120. ANALYSIS OF ALGORITHMS.

Cat. II

This course develops the skill of analyzing the behavior of algorithms.

Topics include the analysis, with respect to average and worst case behavior and correctness, of algorithms for internal sorting, pattern matching on strings, graph algorithms, and methods such as recursion elimination, dynamic programming, and program profiling.

Students will be expected to write and analyze programs.

Undergraduate credit may not be earned both for this course and for CS 504.

Recommended background: CS 2223 and some knowledge of probability.

This course will be offered in 2012-13 and in alternating years thereafter.

CS 4123. THEORY OF COMPUTATION.

Cat. II

Building on the theoretical foundations from CS 3133, this course addresses the fundamental question of what it means to be “computable,” including different characterization of computable sets and functions.

Topics include the halting problem, the Church-Turing thesis, primitive recursive functions, recursive sets, recursively enumerable sets, NP-completeness, and reducibilities.

Students will be expected to complete a variety of exercises and proofs.

Recommended Background: CS 3133.

This course will be offered in 2011-12 and in alternating years thereafter.

CS 4233. OBJECT-ORIENTED ANALYSIS AND DESIGN.

Cat. II

This Software Engineering course will focus on the process of Object-Oriented Analysis and Design. Students will be expected to complete a large number of exercises in Domain Modeling, Use Case Analysis, and Object-Oriented Design.

In addition, the course will investigate Design Patterns, which are elements of reusable object-oriented software designs. This course will survey a set of design patterns and consider how these patterns are described and used to solve design problems.

Recommended Background: CS 2303 and CS 3733.

This course will be offered in 2012-13 and in alternating years thereafter.

CS 4241. WEBWARE: COMPUTATIONAL TECHNOLOGY FOR NETWORK INFORMATION SYSTEMS.

Cat. I

This course explores the computational aspects of network information systems as embodied by the World Wide Web (WWW). Topics include: languages for document design, programming languages for executable content, scripting languages, design of WWW based human/computer interfaces, client/server network architecture models, high level network protocols (e.g., http), WWW network resource discovery and network security issues.

Students in this course will be expected to complete a substantial software project (e.g., Java based user interface, HTML/CGI based information system, WWW search mechanisms).

Recommended background: CS 2102 and CS 3013.

CS 4341. INTRODUCTION TO ARTIFICIAL INTELLIGENCE.

Cat. I

This course studies the problem of making computers act in ways which we call “intelligent”.

Topics include major theories, tools and applications of artificial intelligence, aspects of knowledge representation, searching and planning, and natural language understanding.

Students will be expected to complete projects which express problems that require search in state spaces, and to propose appropriate methods for solving the problems.

Undergraduate credit may not be earned both for this course and for CS 534.

Recommended background: CS 2102, CS 2223, and CS 3133.

CS 4401. SOFTWARE SECURITY ENGINEERING.

Cat. I

This course provides an introduction to the pitfalls and practices of building secure software applications. Topics will include threat modeling, secure software development, defensive programming, web security and the interaction between security and usability. The course focuses on the application level with minor attention to operating-system level security; network-level security is not covered. Assignments involve designing and implementing secure software, evaluating designs and systems for security-related flaws, and presentations on security issues or tools. All students will be required to sign a pledge of responsible conduct at the start of the course.

Recommended Background: CS3013 and CS3733. The course assumes nontrivial experience with C and Unix, familiarity with operating systems, filesystems, and databases, and experience with technologies for building web applications (from CS4241 or personal experience).

CS 4432. DATABASE SYSTEMS II.

Cat. II

This course concentrates on the study of the internals of database management systems. Topics include principles and theories of physical storage management, advanced query languages, query processing and optimization, index structures for relational databases, transaction processing, concurrency control, distributed databases, and database recovery, security, client server and transaction processing systems. Students may be expected to design and implement software components that make up modern database systems.

Undergraduate credit may not be earned both for this course and CS 542.

Recommended background: CS 3431 and CS 3733.

This course will be offered in 2011-12 and in alternating years thereafter.

CS 4445. DATA MINING AND KNOWLEDGE DISCOVERY IN DATABASES.

Cat. II

This course provides an introduction to Knowledge Discovery in Databases (KDD) and Data Mining. KDD deals with data integration techniques and with the discovery, interpretation and visualization of patterns in large collections of data. Topics covered in this course include data warehousing and mediation techniques: data mining methods such as rule-based learning, decision trees, association rules and sequence mining; and data visualization. The work discussed originates in the fields of artificial intelligence, machine learning, statistical data analysis, data visualization, databases, and information retrieval. Several scientific and industrial applications of KDD will be studied.

Recommended background: MA 2611, CS 2223, and CS 3431, or CS 3733.

This course will be offered in 2012-13 and in alternating years thereafter.

CS 4513. DISTRIBUTED COMPUTING SYSTEMS.

Cat. I

This course extends the study of the design and implementation of operating systems begun in CS 3013 to distributed and advanced computer systems.

Topics include principles and theories of resource allocation, file systems, protection schemes, and performance evaluation as they relate to distributed and advanced computer systems.

Students may be expected to design and implement programs that emphasize the concepts of file systems and distributed computing systems using current tools and languages.
Undergraduate credit may not be earned both for this course and for CS 502.

**Recommended background:** CS 3013, CS 3516, and system programming experience.

**CS 4515. COMPUTER ARCHITECTURE.**

*Cat. II*

This course explores the architectural design of modern computer systems in terms of instruction sets and the organization of processors, controllers, memories, devices, and communication links. Topics include an overview of computer architectures and system components, theoretical foundations, instruction-level and thread-level pipelining, multifunction pipelines, multi-core systems, caching and memory hierarchies, and multi-core and parallel computer organization. Students may be expected to design and implement programs that simulate significant components of modern computer architectures.

Recommended background: CS 2011 or ECE 2801, and CS 3013.

This course will be offered in 2012-13 and in alternating years thereafter.

**CS 4516. ADVANCED COMPUTER NETWORKS.**

*Cat II*

This course provides an in-depth look into computer networks. While repeating some of the areas from CS3516, the goal is to go deeper into computer networks topics. This in-depth treatment in topics such as routing, congestion control, wireless layer protocols and physical signaling considerations will require the use of basic queuing theory and probability to provide a more formal treatment of computer networks performance. Other topics covered include: LAN and WLAN technologies, mobile wireless networks, sensor networks, optical networks, network security, intrusion detection and network management.

Students will be expected to do more sophistical network programming than seen in CS3516 and will conduct laboratory activities involving measuring the performance of modern networking applications running on both wired networks and infrastructure wireless networks.

Undergraduate credit may not be earned both for this course and for CS 513.

Recommended background: CS 3013, CS3516 and knowledge of probability.

This course will be offered in 2011-12 and in alternating years thereafter.

**CS 4533. TECHNIQUES OF PROGRAMMING LANGUAGE TRANSLATION.**

*Cat. II*

This course studies the compiling process for high-level languages.

Topics include lexical analysis, syntax analysis, semantic analysis, symbol tables, intermediate languages, optimization, code generation and run-time systems.

Students will be expected to use compiler tools to implement the front end, and to write a program to implement the back end, of a compiler for a recursive programming language.

Undergraduate credit may not be earned for both this course and for CS 544.

Recommended Background: CS 2102 and CS 3133.

This course will be offered in 2012-13 and in alternating years thereafter.

**CS 4536. PROGRAMMING LANGUAGES.**

*Cat. II*

This course covers the design and implementation of programming languages. Topics include data structures for representing programming languages, implementing control structures (such as functions, recursion, and exceptions), garbage collection, and type systems. Students will be expected to implement several small languages using a functional programming language.

Recommended background: CS 2303, CS 3133, and experience programming in a functional language (as provided by CS 1101 or CS 1102).

Undergraduate credit may not be earned for both this course and CS 536.

This course will be offered in 2011-12 and in alternating years thereafter.

**CS 4731. COMPUTER GRAPHICS.**

*Cat. I*

This course studies the use of the computer to model and graphically render two- and three-dimensional structures.

Topics include graphics devices and languages, 2- and 3-D object representations, and various aspects of rendering realistic images.

Students will be expected to implement programs which span all stages of the 3-D graphics pipeline, including clipping, projection, arbitrary viewing, hidden surface removal and shading.

Undergraduate credit may not be earned both for this course and for CS 543.

Recommended background: CS 2223, CS 2303 and MA 2071.

**CS 4732. COMPUTER ANIMATION.**

*Cat. II*

This course provides an in-depth examination of the algorithms, data structures, and techniques used in modeling and rendering dynamic scenes. Topics include animation hardware and software, parametric blending techniques, modeling physical and articulated objects, forward and inverse kinematics, key-frame, procedural, and behavioral animation, and free-form deformation. Students will be expected to develop programs to implement low-level animation algorithms as well as use commercial animation tools to design and produce small to moderate sized animations.

Recommended background: CS 4731.

This course will be offered in 2012-13 and in alternating years thereafter.

**ELECTRICAL AND COMPUTER ENGINEERING**

The second digit in electrical engineering course numbers is coded as follows:

<table>
<thead>
<tr>
<th>0</th>
<th>Circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fields</td>
</tr>
<tr>
<td>2</td>
<td>Electronic Circuits and Systems</td>
</tr>
<tr>
<td>3</td>
<td>Signals and Communication Systems</td>
</tr>
<tr>
<td>4</td>
<td>Available for Future Use</td>
</tr>
<tr>
<td>5</td>
<td>Machines, Power Systems</td>
</tr>
<tr>
<td>6</td>
<td>Professional and Miscellaneous</td>
</tr>
<tr>
<td>7</td>
<td>Projects, Laboratory, Independent Study</td>
</tr>
<tr>
<td>8</td>
<td>Computers</td>
</tr>
<tr>
<td>9</td>
<td>Electronic Devices</td>
</tr>
</tbody>
</table>

**NOTE:** Courses listed in previous catalogs with “EE” as the prefix and the same course number as below are considered to be the SAME COURSE.

**ECE 1799. FRONTIERS AND CURRENT ISSUES OF ELECTRICAL AND COMPUTER ENGINEERING.**

*Cat. I (1/6 unit semester course, spread out evenly over A and B terms)*

This is a seminar-based course intended for First Year students seeking to understand the breadth of activities, career choices and technology that are considered to comprise Electrical and Computer Engineering. Students considering ECE as a major, both those who are "decided" as well as those who are "undecided" should enroll in ECE 1799. The class meets once a week during the fall semester (A & B terms).

Note: There are no "recommended" or “suggested” courses for this description.

**ECE 2010. INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEERING.**

The objective of this course is to introduce students to the broad field of electrical and computer engineering within the context of real world applications. This course is designed for first-year students who are considering ECE as a possible major or for non-ECE students fulfilling an out-of-major degree requirement.

The course will introduce basic electrical circuit theory as well as analog and digital signal processing methods currently used to solve a variety of engineering design problems in areas such as entertainment and networking media, robotics, renewable energy and biomedical applications. Laboratory experiments based on these applications are used to reinforce basic concepts and develop laboratory skills, as well as to provide system-level understanding. Circuit and system simulation analysis tools are also introduced and emphasized.

Topics: Basic concepts of AC/DC and Digital electrical circuits, power, linear circuit simulation and analysis, op-amp circuits, transducers, feedback, circuit equivalents and system models, first order transients, the description of sinusoidal signals and system response, analog/digital conversion, basic digital logic gates and combinatorial circuits.

Recommended Background: high school physics, and MA 1022 (concurrent).

**ECE 2022. INTRODUCTION TO DIGITAL CIRCUITS AND COMPUTER ENGINEERING.**

*Cat. I*

The objective of this course is to expose students (including first year students) to basic electrical and mathematical concepts that underlie computer engineering while continuing an introduction to basic concepts of circuits and systems in a hands-on environment. Experiments representing practical devices introduce basic electrical engineering concepts and skills which typify the study and
practice of electrical and computer engineering. In the laboratory, the students construct, troubleshoot, and test analog and digital circuits that they have designed. They will also be introduced to the nature of the interface between hardware and software in a typical microprocessor based computer.

Topics: Sets, functions, Boolean algebra, digital switching logic, the transistor as switch, circuit design of logic gates, design of combinational logic circuits, software and hardware interfacing including analog/digital and digital/analog conversion.

Recommended background: ECE 2010 and MA 1022.

ECE 2111. FUNDAMENTALS OF ELECTRICAL CIRCUITS. Cat. I

This course provides a firm foundation in DC and AC circuit analysis. It reviews Kirchhoff’s current and voltage laws and the voltage/current relationships for basic two-terminal elements (resistors, capacitors, inductors and sources).

Methods of linear systems analysis are introduced including Thevenin and Norton’s theorems and the superposition principle. Capacitance, inductance and mutual inductance are explored as energy storage elements in the context of first- and second-order transient analysis, including the phenomenon of resonance. Steady-state sinusoidal analysis is presented through the use of complex numbers, phasors, impedance, frequency response and simple passive filter theory. The concepts of conservation of energy and power are introduced, and the course includes coverage of AC power. Concepts may be reinforced with the use of computer simulation.

Recommended background: ECE 2010, MA 1024, PH 1120/21.

Suggested background: MA 2051 (concurrent).

ECE 2112. ELECTROMAGNETIC FIELDS. Cat. I

The object of this course is a comprehensive treatment of electromagnetic engineering principles covering the entire application spectrum from static to dynamic field phenomena.

The starting point will be the basic electric and magnetic field definitions of Coulomb and Biot-Savart leading to Gauss’s and Ampere’s laws. They form the foundation of electro- and magnetostatics fields. Students will examine capacitive and inductive systems and relate them to lumped element circuit models. By introducing temporal and spatial magnetic flux variations, Faraday’s law is established. The engineering implications of this law are investigated in terms of transformer and motor actions. Incorporation of the displacement current density into Ampere’s law and combining it with Faraday’s law will then culminate in the complete set of Maxwell’s field equations. As a result of these equations, students will develop the concept of wave propagation in the time and frequency domain with practical applications such as wireless communication, radar, Global Positioning Systems, and microwave circuits.

Recommended background: ECE 2111.

ECE 2201. MICROELECTRONIC CIRCUITS I. Cat. I

This course is the first of a two-course sequence in electronic circuit design. It begins with a substantive treatment of the fundamental behavior of semiconductor materials and moves on to the semiconductor diode, the bipolar transistor, and the field-effect transistor. Laboratory exercises are provided to reinforce the theory of operation of these devices. Numerous circuit applications are considered, including: power supplies, transistor amplifiers, and FET switches.

Topics include: the pn junction, diode operation, transducers, rectification, voltage regulation, limiting and clamping circuits, transistor operation, biasing, small-signal and large-signal models, transistors amplifiers, and switching applications.

Recommended background: ECE 2111.

ECE 2305. INTRODUCTION TO COMMUNICATIONS AND NETWORKS. Cat. II

This course provides an introduction to the broad area of communications and networking, covering the context and fundamental knowledge appropriate for all electrical and computer engineers, as well as for further study in this area. The course is organized as a systems approach to communications and networking. Topics include key concepts and terminology (delay, loss, throughput, bandwidth, etc.), types of transmission media, addressing, switching, routing, networking principles and architectures, networking protocols, regulatory and applications issues.

Recommended background: ECE 2010.

This course will be offered in 2012-13 and in alternating years thereafter.

ECE 2311. CONTINUOUS-TIME SIGNAL AND SYSTEM ANALYSIS. Cat. I

This course provides an introduction to time and frequency domain analysis of continuous time signals and linear systems. Topics include signal characterization and operations; singularity functions; impulse response and convolution; Fourier series; the Fourier transform and its applications; frequency-domain characterization of linear, time-invariant systems such as filters; and the Laplace transform and its applications.

Recommended background: ECE 2111, MA 1022.

Suggested background: MA 2051.

ECE 2312. DISCRETE-TIME SIGNAL AND SYSTEM ANALYSIS. Cat. I

This course provides an introduction to the time and frequency domain analysis of discrete-time signals and linear systems. Topics include sampling and quantization, characterization of discrete-time sequences, the discrete-time Fourier transform, the discrete Fourier transform and its applications, the Z transform and its applications, linear and circular convolution, characterization of FIR and IIR discrete-time systems, and the analysis and design of discrete-time filters. Projects include topics such as sampling and quantization; application of the DFT to signal and system analysis and design; and digital filter design and simulation.

Recommended background: ECE 2311.

ECE 2799. ELECTRICAL AND COMPUTER ENGINEERING DESIGN. Cat. I

The goal of this course is to provide experience with the design of a system, component, or process. Basic sciences, mathematics, and engineering sciences are applied to convert resources to meet a stated objective. Fundamental steps of the design process are practiced, including the establishment of objectives and criteria, synthesis, analysis, manufacturability, testing, and evaluation. Student work in small teams and are encouraged to use creativity to solve specific but open-ended problems, and then present their results.

ECE 2799 is strongly recommended for all students as a preparation for the design element of the MQP. It is anticipated that ECE 2799 will be of most benefit to students when taken well in advance of the MQP (late sophomore year or early junior year).

Recommended background: ECE 2022 and ECE 2311; and either ECE 2201 or ECE 2801.

ECE 2801. FOUNDATIONS OF EMBEDDED COMPUTER SYSTEMS. Cat. I

This course introduces the C and assembly language programming concepts that are needed to develop microprocessor and microcontroller-based computer systems. Beginning with the fundamentals of computer architecture and organization, students learn assembly language and how C and assembly language programs running on microprocessors are used to solve problems that require interactions between a computer and the physical world. Students in this course will also learn about the hardware and software structure of a modern computer system and how hardware, software, and the passage of time must be managed in an embedded system design. Other issues that will be addressed as appropriate include overall embedded system development, software maintenance, programming for reliability, and product safety.

Topics: Number systems, software flow diagrams, models for system state and state transitions, microprocessor and microcontroller architecture, mixed C and assembly language programming, program development and test tools, operating system interfaces, hardware/software dependencies, and time and resource management.

Lab exercises: Introductory C and assembly language exercises and more advanced problems which explore topics such as logic flow, real time program-
ECE 3311. PRINCIPLES OF COMMUNICATION SYSTEMS.
Cat. I
This course provides an introduction to analog and digital communications systems. The bandpass transmission of analog data is motivated and typical systems are analyzed with respect to bandwidth considerations and implementation techniques. Baseband and passband digital transmission systems are introduced and investigated. Pulse shaping and intersymbol interference criteria are developed in relation to the pulse rate transmission limits of bandlimited channels. Finally, digital carrier systems and line coding are introduced in conjunction with applications to modern modem transmission schemes.
Recommended background: MA 1024 and ECE 2312.
Suggested background: ECE 2305.

ECE 3503. POWER ELECTRONICS.
Cat. I
This course is designed to provide a cohesive presentation of the principles of electric energy conversion for industrial applications and design. The generation, transmission and conversion of electric energy, as well as basic instrumentation and equipment associated with electric energy flow and conversion are analyzed.
Recommended background: ECE 2111.

ECE 3801. ADVANCED LOGIC DESIGN.
Cat. I
This course introduces students to the design of the complex logic systems underlying or supporting the operation of computer systems and interfaces. Students learn how to use advanced computer-aided design tools to develop and simulate logic systems consisting of MSI components such as adders, multiplexers, latches, and counters. The concept of synchronous logic is introduced through the design and implementation of Mealy and Moore machines.
Topics: Review of logic gates and design and simplification of combinational circuits. Arithmetic circuits, MSI devices, analysis and design of sequential circuits, synchronous state machines and programmable logic devices.
Introduction to hardware description languages.
Lab exercises: Design, analysis and construction of combinational and sequential circuits, use of computer-aided engineering software for schematic entry and digital analysis, introduction to hardware description languages and programmable logic devices.
Recommended background: ECE 2201, ECE 2311 or equivalent.

ECE 3803. MICROPROCESSOR SYSTEM DESIGN.
Cat. I
This course builds on the computer system material presented in ECE 2801. It covers the architecture, organization and instruction set of microprocessors. The interface to memory (RAM and EPROM) and I/O peripherals is described with reference to bus cycles, bus timing, and address decoding. Emphasis is placed on the design, programming and implementation of interfaces to microprocessor systems using a mixture of C and assembly language.
Topics: bus timing analysis, memory devices and systems, IO and control signaling, bi-directional bus interfaces, instruction execution cycles, interrupts and polling, addressing, programmable peripheral devices, interface design issues including analog/digital and digital/analog conversion. Mixed language (C and Assembly) programming.
Laboratory exercises: Use of standard buses for advanced IO design and programming, mixed language programming, standard bus timing, and interface design and implementation. Development of a complete standalone embedded computer system.
Recommended background: ECE 2801 and ECE 3801 or an equivalent background in advanced logic design, and microprocessor architecture. CS 2301 or CS 2303 or an equivalent background in C programming.
ECE 3810. ADVANCED DIGITAL SYSTEM DESIGN.
This is an introductory course addressing the systematic design of advanced digital logic systems. The emphasis is on top-down design starting with high level models using VHDL as a tool for the design, synthesis, modeling, and testing of highly integrated digital devices. The integration of tools and design methodologies will be addressed through a discussion of system on a chip (SOC) integration. Topologies, design for performance, and design for testing/verification. Topics: 1) hardware description languages, system modeling, synthesis, simulation and testing of digital circuits; 2) design integration to achieve specific SOC goals including architecture, planning and integration, and testing; 3) use of soft core and IP modules to meet specific architecture and design goals. Laboratory exercises: VHDL models of combinational and sequential circuits, synthesizing these models to programmable logic devices, simulating the design, test-benches, system design and modeling, integration of IP and high level SOC design methodologies. Recommended background: ECE 3801, ECE 2201, and experience with programming in a high-level language such as C.
Suggested background: ECE 3803.
Students may not receive credit for ECE 3810 if they have received credit for either ECE 3815 or ECE 3902.

ECE/BME 4011. BIOMEDICAL SIGNAL ANALYSIS.
Cat. II
Introduction to biomedical signal processing and analysis. Fundamental techniques to analyze and process signals that originate from biological sources: ECGs, EMGs, EEGs, blood pressure signals, etc. Course integrates physiological knowledge with the information useful for physiologic investigation and medical diagnosis and processing. Biomedical signal characterization, time domain analysis techniques (transfer functions, convolution, auto- and cross-correlation), frequency domain (Fourier analysis), continuous and discrete signals, deterministic and stochastic signal analysis methods, Analog and digital filtering. Recommended background: ECE 2511, ECE 2312, BME 3011, or equivalent.
This course will be offered in 2012-13, and in alternating years thereafter.

ECE 4305. SOFTWARE-DEFINED RADIO SYSTEMS AND ANALYSIS.
Cat. I
This course provides students with hands-on exposure to the design and implementation of modern digital communication systems using software-defined radio technology. The prototyping and real-time experimentation of these systems via software-defined radio will enable greater flexibility in the assessment of design trade-offs as well as the illustration of “real world” operational behavior. Performance comparisons with quantitative analytical techniques will be conducted in order to reinforce digital communication system design concepts. In addition to laboratory modules, a final course project will synthesize topics covered in class. Course topics include software-defined radio architectures and implementations, digital signaling and data transmission analysis in noise, digital receiver structures (matched filtering, correlation), multicarrier communication techniques, radio frequency spectrum sensing and identification (energy detection, matched filtering), and fundamentals of radio resource management.
Recommended background: ECE 3311, MA 2621, familiarity with Simulink, familiarity with general programming.

ECE 4703. REAL-TIME DIGITAL SIGNAL PROCESSING.
Cat. I
This course provides an introduction to the principles of real-time digital signal processing (DSP). The focus of this course is hands-on development of real-time signal processing algorithms using audio-based DSP kits in a laboratory environment. Basic concepts of DSP systems including sampling and quantization of continuous time signals are discussed. Tradeoffs between fixed-point and floating-point processing are exposed. Real-time considerations are discussed and efficient programming techniques leveraging the pipelined and parallel processing architecture of modern DSPs are developed. Using the audio-based DSP kits, students will implement real-time algorithms for various filtering structures and compare experimental results to theoretical predictions. Recommended background: ECE 2312, ECE 2801, some prior experience in C programming.
Suggested background: ECE 3311.

ECE 4801. ADVANCED COMPUTER SYSTEM DESIGN.
Cat. I
This course continues the development of advanced computer systems and focuses on the architectural design of standalone embedded and high-performance microprocessor systems. Topics: advanced microprocessor architecture, embedded systems, RISC and CISC, interrupts, pipelining, DMA, cache and memory system design, high-performance system issues.
Recommended background: ECE 3803 or equivalent.

ECE 4902. ANALOG INTEGRATED CIRCUIT DESIGN.
Cat. I
This course introduces students to the design and analysis of analog integrated circuits such as operational amplifiers, phase-locked loops, and analog multipliers. Topics: integrated circuit building blocks: current mirrors and sources, differential amplifiers, voltage references and multipliers, output circuits. Computer-aided simulation of circuits. Layout of integrated circuits. Design and analysis of such circuits as operational amplifiers, phase-locked loops, filters, and analog multipliers. Laboratory exercises.
Recommended background: familiarity with the analysis of linear circuits and with the theory of bipolar and MOSFET transistors. Such skills are typically acquired in ECE 3204.
Suggested background: ECE 4904.

ECE 4904. SEMICONDUCTOR DEVICES.
Cat. II
The purpose of this course is to introduce students to the physics of semiconductor devices and to show how semiconductor devices operate in typical linear and nonlinear circuit applications. This material complements the electronics sequence of courses and will draw illustrative examples of electronic circuit applications from other courses. Topics: carrier transport processes in semiconductor materials. Carrier lifetime. Theory of p-n junctions. Bipolar transistors internal theory, dc characteristics, charge control, Ebers-Moll relations; high frequency and switching characteristics, hybrid-pi model; n- and p-channel MOSFETS, CMOS.
Recommended background: ECE 2201. Suggested background: ECE 3204 (helpful but not necessary).
Students may not receive credit for ECE 4904 if they have received credit for ECE 3901.
This course will be offered in 2012-13, and in alternating years thereafter.

ENGINEERING SCIENCE INTERDISCIPLINARY

ES 1020. INTRODUCTION TO ENGINEERING.
Cat. I
This course is for first year students with an interest in engineering. The course focuses on the design process. Students are introduced to engineering through case studies and reverse engineering activities. Students will learn the steps in the design process and how engineers use this process to create new devices. Teams of students are then assigned a design project that culminates in building and evaluating a prototype in their design. Results of the design project are presented in both oral and written reports. This course does not require any prior engineering background.
Note: This course can be used towards the Engineering Science and Design distribution requirement in IE, ME, and MFE.

ES 1310. INTRODUCTION TO COMPUTER AIDED DESIGN.
Cat. I
This basic course in engineering graphical communications provides a background for all engineering disciplines. The ability to create and interpret standard, well-integrated detail and assembly drawings is a necessity for engineers to communicate ideas. Computer Aided Design software will be used as a tool for creating these engineering design drawings. Multiview and pictorial graphics techniques are integrated with standards for dimensioning, sectioning, and generating detailed engineering drawings. Emphasis is placed on relating drawings to the required manufacturing processes. The design process and aids to creativity are combined with graphics procedures to incorporate functional design requirements in the geometric model.
No prior engineering graphics or software knowledge is assumed.
ES 2904. FLUID MECHANICS.  
Cat. I  
A study of the fundamental laws of statics, kinematics and dynamics applied to fluid mechanics. The course will include fluid properties, conservation of mass, momentum and energy as applied to real and ideal fluids. Laminar and turbulent flows, fluid resistance and basic boundary layer theory will also be considered. Recommended background: basic physics, basic differential equations and vectors; third year students.

ES 3001. INTRODUCTION TO THERMODYNAMICS.  
Cat. I  
This course emphasizes system and control volume modeling using the First and Second Laws of Thermodynamics.  
Topics include: properties of simple substances, an introduction to availability, cycle analysis.

ES 3002. MASS TRANSFER.  
Cat. I  
This course introduces the student to the phenomena of diffusion and mass transfer. These occur in processes during which a change in chemical composition of one or more phases occurs. Diffusion and mass transfer can take place in living systems, in the environment, and in chemical processes. This course will show how to handle quantitative calculations involving diffusion and/or mass transfer, including design of process equipment.  
Topics may include: fundamentals of diffusional transport, diffusion in thin films; unsteady diffusion; diffusion in solids; convective mass transfer; dispersion; transport in membranes; diffusion with chemical reaction; simultaneous heat and mass transfer; selected mass transfer operations such as absorption, distillation, humidification, extraction, crystallization, adsorption, etc.  
Recommended background: fundamentals of chemical thermodynamics, fluid flow and heat transfer; ordinary differential equations (MA 2051 or equivalent).

ES 3003. HEAT TRANSFER.  
Cat. I  
To provide an understanding of fundamental concepts of heat fluxes, to develop understanding of the coupling of fluid mechanics and thermodynamics, and to provide experience in modeling engineering systems and predicting their behavior.  
Topics covered include: steady-state and transient conduction exemplified by heat transfer to and from buried pipes, heat losses through furnace walls, response of thermocouple devices, and the effect of adding fins to increase heat transfer rates.  
Recommended background: Ordinary Differential Equations (MA 2051).

ES 3004. FLUID MECHANICS.  
Cat. I  
A study of the fundamental laws of statics, kinematics and dynamics applied to fluid mechanics. The course will include fluid properties, conservation of mass, momentum and energy as applied to real and ideal fluids. Laminar and turbulent flows, fluid resistance and basic boundary layer theory will also be considered. Recommended background: basic physics, basic differential equations and vectors; third year students.

ES 3011. CONTROL ENGINEERING I.  
Cat. I  
This sequence of courses in the field of control engineering (ES 3011) is generally available to all juniors and seniors regardless of department. A good background in mathematics is required; familiarity with Laplace transforms, complex variables and matrices is desirable but not mandatory. All students taking Control Engineering I should have an understanding of ordinary differential equations (MA 2051 or equivalent) and basic physics through electricity and magnetism (PH 1120/1121). Control Engineering I may be considered a terminal course, or it may be the first course for those students wishing to do extensive work in this field. Students taking the sequence of two courses will be prepared for graduate work in the field.  
Recommended background: Ordinary Differential Equations (MA 2051) and Electricity and Magnetism (PH 1120, PH 1121).

ES 3325. ADVANCED COMPUTER AIDED DESIGN.  
Cat. I  
This course exposes the student to computer aided engineering design and geometric modeling using Unix based graphic workstations. The use of geometric models for applications in computer aided mechanical design, engineering analysis and manufacturing is emphasized. Topics may include mechanical design, solid and feature based modeling, variational and parametric design, physical properties, assembly modeling, numerical control, mechanisms, and other analytical methods in engineering design.  
Recommended background: familiarity with drafting standards (ES 1310), mechanical systems (ES 2501 or CE 2000, ES 2503) and kinematics (ME 3310) is assumed. Additional background in strength of materials (ES 2502 or CE 2001), machine design (ME 2300, ME 3320), machining and manufacturing methods (ME 1800) and higher level programming capability (CS 1101 or CS 1102) is helpful.
FIRE PROTECTION ENGINEERING COURSES

FIRE PROTECTION ENGINEERING

FP 3070. FUNDAMENTALS OF FIRESAFETY ANALYSIS.
Cat. I
This course introduces students of different technical disciplines to analytical methods and techniques to address problems of fire, explosions, or hazardous incidents. Emphasis will be placed on understanding the physical concepts of the problem and their interactions. Quantification will adapt existing procedures to appropriate levels of theoretical and empirical methods in the field of fire science and engineering. Computer applications will be incorporated.
Recommended background: mathematics through differential equations; engineering science; fluid mechanics.

Graduate Fire Protection Engineering Courses of Interest to Undergraduates

FPE 520. FIRE MODELING.
(Prerequisite: FPE 521 or special permission of the instructor.) Advanced topics in fire dynamics, combustion and compartment fire behavior will be discussed within a framework of modeling fire and its effects. Topics include computer modeling of pre-flashover and post-flashover compartment fires, burning characteristics of polymers and other fuels, the effect of fire retardants, products of combustion generation, flame spread models, plume and ceiling jet models and overall toxicity assessment. Some familiarity with computer programming is recommended.

FPE 521. FIRE DYNAMICS I.
(Prerequisites: Undergraduate chemistry, thermodynamics (or physical chemistry), fluid mechanics and heat transfer.) This course introduces students to fundamentals of fire and combustion and is intended to serve as the first exposure to fire dynamics phenomena. The course includes fundamental topics in fire and combustion such as thermodynamics of combustion, fire chemistry, premixed and diffusion flames, solid and liquid burning, ignition, plumes and ceiling jets. These topics are then used to develop the basic models of compartment fire behavior, pre and post-flashover conditions and smoke movement.

FPE 553. FIRE PROTECTION SYSTEMS.
(Prerequisites: Undergraduate courses in chemistry, fluid mechanics and either thermodynamics or physical chemistry.) This course provides an introduction to automatically activated fire suppression and detection systems. A general overview is presented of relevant physical and chemical phenomena and commonly used hardware in automatic sprinkler, gaseous agent, foam and dry chemical systems. Typical contemporary installations and current installation and approval standards are reviewed.

FPE 554. ADVANCED FIRE SUPPRESSION.
(Prerequisite: FPE 553 or special permission of instructor.) Advanced topics in suppression systems analysis and design are discussed with an aim toward developing a performance based understanding of suppression technology. Automatic sprinkler systems are covered from the standpoint of predicting actuation times, reviewing numerical methods for hydraulic analyses of pipe flow networks and understanding the phenomenology involved in water spray suppression. Special suppression systems are covered from the standpoint of two phase and non-Newtonian pipe flow and simulations of suppression agent discharge and mixing in an enclosure.

FPE 555. DETECTION, ALARM AND SMOKE CONTROL.
(Prerequisites: FPE 553. Also FPE 521 and FPE 571 which can be taken concurrently.)
Principles of fire detection and using flame, heat and smoke detector technology are described. Fire alarm technology and the electrical interface with fire/smoke detectors are reviewed in the context of contemporary equipment and installation standards. Smoke control systems based on buoyancy and HVAC principles are studied in the context of building smoke control for survivability and safe egress.

FPE 563 (OIE 541). OPERATIONS RISK MANAGEMENT.
Risk Management is highly interdisciplinary drawing upon systems engineering and managerial decision making and finance. The basics of risk management including hazard analysis, risk assessment, risk control and risk financing are covered. The course is self-contained and includes material from engineering economy, risk assessment and decision analysis. Group projects can draw from fire protection engineering, hazardous waste management and product liability. The projects serve to emphasize important techniques for quantifying risk and the challenge of integrating risk assessment with managerial decision making.

FPE 570. BUILDING FIRESAFETY I.
This course focuses on the presentation of qualitative and quantitative means for firesafety analysis in buildings. Fire test methods, fire and building codes and standards of practice are reviewed in the context of a systematic review of firesafety in proposed and existing structures.

FPE 571. PERFORMANCE-BASED DESIGN.
(Prerequisites: FPE 553, FPE 521 and FPE 570 or special permission of instructor.) This course covers practical applications of fire protection engineering principles to the design of buildings. Both compartmented and non-compartmented buildings will be designed for criteria of life safety, property protection, continuity of operations, operational management and cost. Modern analytical tools as well as traditional codes and standards are utilized. Interaction with architects, code officials and an awareness of other factors in the building design process are incorporated through exercises and a design studio.

FPE 572. FAILURE ANALYSIS.
(Prerequisites: FPE 570, FPE 521 and FPE 553 or special permission of the instructor.) Development of fire investigation and reconstruction as a basis for evaluating, and improving firesafety design. Accident investigation theory and failure analysis techniques such as fault trees and event sequences are presented. Fire dynamics and computer modeling are applied to assess possible fire scenarios and the effectiveness of fire protection measures. The products liability aspects of failure analysis are presented. Topics include products liability law, use of standard test methods, warnings and safe product design. Application of course materials is developed through projects involving actual case studies.

FPE 573. INDUSTRIAL FIRE PROTECTION.
(Prerequisites: FPE 553, FPE 521 or special permission of instructor.) Principles of fire dynamics, heat transfer and thermodynamics are combined with a general knowledge of automatic detection and suppression systems to analyze fire protection requirements for generic industrial hazards. Topics covered include safe separation distances, plant layout, hazard isolation, smoke control, warehouse storage and flammable liquid processing and storage. Historical industrial fires influencing current practice on these topics are also discussed.

FPE 575. EXPLOSION PROTECTION.
Principles of combustion explosions are taught along with explosion hazard and protection applications. Topics include a review of flammability limit concentrations for flammable gases and dusts; thermochemical equilibrium calculations of adiabatic closed vessel deflagration pressures and detonation pressures and velocities; pressures development as a function of time for closed vessels and vented enclosures; the current status of explosion suppression technology; and vapor cloud explosion hazards.

FPE 580. SPECIAL PROBLEMS.
Individual or group studies on any topic relating to fire protection may be selected by the student and approved by the faculty member who supervises the work.

FPE 581. SEMINAR.
Reports on current advances in the various branches of fire protection.

FPE 587. FIRE SCIENCE LABORATORY.
(Prerequisite: FPE 521.) This course provides overall instruction and hands-on experience with fire science related experimental measurement techniques. The objective is to expose students to laboratory-scale fire experiments, standard fire tests and state-of-the-art measurement techniques. The Lateral Ignition and Flame Transport (LIFT) apparatus, state-of-the-art smoke detection systems, closed-up flashpoint tests and gas analyzers are among the existing laboratory apparatus. Fire related measurement techniques for temperature, pressure, flow and velocity, gas species and heat fluxes, infrared thermometry, Laser Doppler Velocimetry (LDV) and Laser Induced Fluorescence (LIF) will be reviewed.

FPE 590. M. S. THESIS.

FPE 690. PH.D. DISSERTATION.
HUMANITIES AND ARTS

ART HISTORY/ARCHITECTURE (AR)

AR 1100. ESSENTIALS OF ART.
Cat. I
This course provides an introduction to the basic principles of two and three-dimensional visual organization. The course focuses on graphic expression, idea development, and visual literacy. Students will be expected to master basic rendering skills, perspective drawing, concept art, and storytelling through traditional and/or computer-based tools.

AR 1101. DIGITAL IMAGING AND COMPUTER ART.
Cat. I
This course focuses on the methods, procedures and techniques of creating and manipulating images through electronic and digital means. Students will develop an understanding of image alteration. Topics may include color theory, displays, modeling, shading, and visual perception.
Recommended background: AR 1100.

AR 1111. INTRODUCTION TO ART HISTORY.
Cat. I
How do we understand a work of art? Through readings and the study of objects at the Worcester Art Museum, the student will survey the major developments in world art and be introduced to various critical perspectives in art history. Students will learn how art historians work with primary materials and formulate arguments. No previous knowledge of art is required. (Formerly HU 1014.)

AR/IMGD 2101. 3D MODELING.
Cat. I
This course focuses on the art of 3D computer modeling for graphics, animation, game design, and image visualization. Techniques in polygon, NURB, and subdiv modeling will be explored, as well as deformations, texture mapping, lighting, cameras, rendering, and MEL scripting. Realistic and stylized modeling concepts will be developed, including optimization for rigging and game design. Historical context in relation to traditional sculpture will be discussed.
Recommended background: AR1100 and AR1101.

AR 2111. MODERN ART.
Cat. I
The successive phases of modern art, especially painting, are examined in light of the late-19th-century break with the 600-year-old tradition of representation. Topics covered include: non-objective art and abstraction—theory and practice, primitivism in modern art, surrealism and the irrational, the impact of photography on modern painting, cubism and collage, regionalism and abstract expressionism as American art forms, Pop art and popular culture, and the problem of concept versus representation in art. (Formerly AR 2300.)

AR 2114. MODERN ARCHITECTURE IN THE AMERICAN ERA, 1750-2001 AND BEYOND.
Cat. I
This course studies, in a non-technical way, America's buildings and places, in the context of world architecture in modern times. The history of American architecture was shaped by the forces that shaped America, from its political emergence in the eighteenth century to the post-9/11 era. These forces include dreams of social and spiritual perfection; a tight and conflicted relation with nature; and the rise and spread of industrial capitalism. The same forces created the Modern Movement in architecture. How are modernism and American architecture intertwined? Illustrated lectures, films, and tours of Worcester architecture explore the question, while training students in the methods of architectural history and criticism.
Students who have taken AR 2113, Topics in 19th- and 20th-Century Architecture, since the 2000-2001 academic year MAY NOT take AR 2114 for credit.

AR/IMGD 2201. THE ART OF ANIMATION.
Cat. I
This course examines the fundamentals of computer generated 2D and 3D modeling and animation as they apply to creating believable characters and environments. Students will learn skeletal animation and traditional polygonal animation, giving weight and personality to characters through movement, environmental lighting, and changing mood and emotion. Students will be expected to master the tools of 3D modeling and skinning, and scripting of behaviors.
Recommended background: AR 1101.

ENGLISH (EN)

EN 1221. INTRODUCTION TO DRAMA: THEATRE ON THE PAGE AND ON THE STAGE.
Cat. I
This introductory course will give the student an understanding of the forms of drama, the styles of theatre performance and production, and the emergence of new forms and styles. Research and writing projects, and performance activities will offer the student experience in the theory and practice studied in the course.

EN 1222. SHAKESPEARE IN THE AGE OF ELIZABETH.
Cat. I
This course is an introduction to Shakespeare, his theatre, and some important concepts of his world. Students will have the opportunity to sample representative Shakespearean tragedies, comedies, and histories. In addition to class discussions and scene work, students will be able to enhance their readings by analyzing video recordings of the plays.

EN 1231. AMERICAN LITERATURE: BEGINNINGS THROUGH HAWTHORNE.
Cat. I
This survey course covers American literature from its beginnings in the colonial period through the works of Nathaniel Hawthorne in the early nineteenth century. Students will read literary works in a variety of genres (narratives, poems, sermons, plays, stories, and novels) that reflect the emerging nation's struggle for cultural self-definition. Topics will include the literature of travel and discovery, the faith of the colonial founders, the quest for a distinctive national literature, and the rise of early American fiction.

EN 1242. INTRODUCTION TO ENGLISH POETRY.
Cat. I
This course surveys the poems of our language. From the Anglo-Saxon poems to the popular verse of Tennyson, the songs and the poets are legion: Chaucer, Raleigh, Spenser, Marlowe, Shakespeare, Jonson, Donne, Herrick, Milton, Blake, Wordsworth, Coleridge, Byron, Keats, Tennyson, Browning, and Hopkins. The England that nourished these writers will be viewed through their ballads, lyrics, sonnets, epigrams, and odes. “Not marble nor the gilded monuments of princes shall outlive this powerful rhyme.”
EN 1251. INTRODUCTION TO LITERATURE.
Cat. I
This course introduces the student to a variety of critical perspectives necessary to an understanding and appreciation of the major forms, or genres, of literary expression (e.g., novel, short story, poetry, drama, and essay). Writing and class discussion will be integral parts of this course.

EN 1257. INTRODUCTION TO AFRICAN AMERICAN LITERATURE AND CULTURE.
Cat. II
This course examines the formation and history of the African American literary tradition from slave narratives to contemporary forms in black popular culture. The course will explore some genres of African American writing and their relation to American literature and to black cultural expression.

EN/WR 2210. INTRODUCTION TO PROFESSIONAL WRITING.
Cat. I
This course will serve as a gateway into the Professional Writing major but will also be open—and useful—to any student interested in learning about the standard written genres of professional, workplace communication. Students will analyze the history, purposes, conventions, and social consequences of a variety of professional communication, focusing on digital and print correspondence, reports, and proposals directed to internal and external audiences. Students will learn about the culture of a professional environment and the role of writing in structuring identity and relationships within that context. Classes will be conducted as interactive writing workshops in which students assess and respond to rhetorical scenarios and sample texts from a variety of professional worksites. Students will create portfolios, producing professional writing samples they may use on the job market.

EN/WR 2211. ELEMENTS OF WRITING.
Cat. I
This course is designed for students who wish to work intensively on their writing. The course will emphasize the processes of composing and revising, the rhetorical strategies of written exposition and argumentation, and the reading and citation practices central to academic inquiry. In a workshop setting, students will write a sequence of short papers and complete one longer writing project based on multiple source texts; learn to read critically and respond helpfully to each other's writing; and make oral presentations from written texts. Where applicable, the topical theme of the class will be provided via the Registrar's office.

EN/WR 2213. INTRODUCTION TO JOURNALISM.
Cat. I
The course is for students who may wish to make careers in journalism or communications and for those who wish to understand the history, function, production and contemporary challenges of print journalism. Students will analyze articles from newspapers, magazines and Web sites. They will learn and practice the skills of the journalist: finding the story, researching, interviewing, writing on deadline, copy-editing and proof-reading. Classes will also cover matters such as objectivity, fairness, ethics and libel, as well as wider issues of mass communication such as agenda setting, citizen journalism and the implications of converging media. To give students a more keen sense of audience, work will be read and discussed in class. Students will be urged to write for the college newspaper. Publication beyond the campus will be strongly encouraged.

EN 2221. AMERICAN DRAMA.
Cat. I
An investigation into the development of American drama from its beginnings to the present. The history of the emergence of the legitimate theatre in this country will be followed by reading important plays, including the works of O'Neill, Williams, Mamet, Norman, Henley, and others. Discussion of the growth of regional theatres and their importance to the continuation of theatre as a serious and non-profit art form will be included in the course. The student will investigate the importance of theatre practice in the evolution of the dramatic literature of the country.

EN 2222. THEATRE WORKSHOP.
Cat. I
A workshop course which offers the student the opportunity to explore theatre through creative involvement with playwriting, design, performance, production, and criticism. Students will work in a laboratory situation functioning as a micro-professional theatre which could develop a production that would be staffed and dramaturged from the group.

EN 2224. SHAKESPEARE: NOTHING BUT LOVE.
Cat. II
The course focuses on conflicts between personal desire and societal responsibility in such plays as As You Like It, Antony and Cleopatra, and The Winter's Tale. Through written work and in-class performances, students will examine how Shakespeare both maintains and subverts traditional ideas about marriage and sexual practice. These analyses will take into account contemporary views on gender roles and identity including the early modern cultural "ideal" of the "chaste, silent, and obedient" woman. Students will study Shakespeare's work as literature and also through performance and film adaptations. The WPI library of video recordings will be available for such work.

This course will be offered in 2012-13 and in alternating years thereafter.

EN 2225. THE LITERATURE OF SIN.
Cat. II
This course begins with selections from John Milton's provocative version of Adam and Eve's original sin in Paradise Lost. Focusing on Milton, John Donne and others, we will examine the theme of sin—political, religious, and sexual—in early modern literature. The events of the English Reformation profoundly influenced these writers, and their personal struggles against societal institutions have greatly influenced subsequent literary expressions of rage and rebellion. Students will also be reading texts by contemporary writers such as David Mamet which address the theme of sin in the modern city.

This course will be offered in 2011-12 and in alternating years thereafter.

Cat. I
Emerson challenged the young nation in "The American Scholar" (1837): If our writers were "free and brave," with words "loaded with life," they would usher in a "new age." The incredibly rich literature that soon followed created an "American Renaissance." This was the Age of Reform (1836-65) in more than literature. Writers were caught up in such burning issues as abolitionism, Union vs. secession, and women's rights. Authors studied may include Emerson, Thoreau, Poe, Fuller, Douglass, Melville, Whitman, and Dickinson.

EN 2232. AMERICAN LITERATURE: TWAIN TO WORLD WAR I.
Cat. I
This survey course covers developments in American literature, particularly the movement towards Realism, during the period of turbulent change between the end of the Civil War and the early years of the twentieth century. Topics will include the rebellion against post bellum sentimentalism, the rise of regional writing, the emerging literature of social protest, and literary responses to advances in science, industry, and urban life. Attention will be given to the works of Mark Twain, a prime exponent of turn-of-the-century literary trends, as well as to other pioneer realists (Wharton and Crane).

EN 2233. AMERICAN LITERATURE: MODERNISM TO THE PRESENT.
Cat. I
This final survey course in American literature covers the modern and contemporary periods, from 1914 to the present, focusing on the literary response to the cultural, intellectual, and social, changes that mark the past century of ferment both within the United States and beyond. The course will include work by dramatists, essayists, novelists, and poets such as Gertrude Stein, William Carlos Williams, Nella Larsen, William Faulkner, Edward Albee, Adrienne Rich, Marilyn Chin, and Sherman Alexie.

EN 2234. MODERN AMERICAN NOVEL.
Cat. II
Selected works of fiction which appeared after World War I will be the focus of this course. F. Scott Fitzgerald, Ernest Hemingway, William Faulkner, or other authors of the early modern period will be studied, but significant attention will also be given to contemporary novelists, such as Alice Walker and Kurt Vonnegut. The cultural context and philosophical assumptions of the novels will be studied as well as their form and technique.

This course will be offered in 2011-12 and in alternating years thereafter.

EN 2235. THE AMERICAN DREAM: MYTH IN LITERATURE AND THE POPULAR IMAGINATION.
Cat. I
American writers from our beginnings have been preoccupied with "The American Dream" as a benchmark for measuring the attainment of our highest ideals as a people. The course examines the political, economic, religious, and rhetorical roots of the concept, assesses its popular and commercial manifesta-
This course surveys the ways in which modern literature has represented science raised by love, religion, death, money, conformity.

EN 2237. LITERATURE AND THE ENVIRONMENT.  Cat. II
This course will examine the many ways in which dramatists, essayists, filmmakers, novelists, and poets have articulated ecological and environmental concerns. Topics to be discussed may include changing attitudes towards terms like 'nature' and 'wilderness,' the effects of technology on the environment, issues of conservation and sustainability, the dynamics of population growth, the treatment of animals, the production of food, and the presence of the spiritual in nature. Materials will include works by writers such as Wendell Berry, Rachel Carson, Winona LaDuke, Wangari Maathai, Thomas Malthus, Arne Naess, Nicolas Roeg, and Gary Snyder.

This course will be offered in 2012-13 and in alternating years thereafter.

EN 2238. AMERICAN REALISM.  Cat. I
By examining authors who reacted against the so-called "gentle tradition," this course attempts to show how various subjects (death, sex, war, slavery, and racial prejudice) were treated more honestly in short stories and novels after the Civil War. Authors may include Mark Twain, Stephen Crane, W. D. Howells, Edith Wharton, Kate Chopin, Theodore Dreiser, and twentieth century realists.

(Formerly EN 3236. Students who have received credit for this course may not receive credit for EN 2238.)

EN 2241. ENGLISH LITERATURE AFTER SHAKESPEARE.  Cat. II
Participants in this course will examine outstanding works of eighteenth- and nineteenth-century English literature as these works raise the question: Who is man, and what is his relationship to God, nature, and to his fellow creatures? Writers covered may include Swift, Pope, Keats, Browning, and Dickens.

This course will be offered in 2012-13 and in alternating years thereafter.

EN 2242. POPULAR FICTION: READING IN INSTALLMENTS.  Cat. I
Students in this course will have the opportunity to read two major masterpieces of English fiction the way they should be read: slowly, carefully, and with relish. Victorian novels are long and the term is short, but by reading novels in the way in which they were read by their original readers—serially—we can experience masterworks by Charles Dickens and George Eliot at comparative leisure, examining one serial installment per class session.

This course will be offered in 2012-13 and in alternating years thereafter.

EN 2243. MODERN BRITISH LITERATURE.  Cat. II
A survey of major modern British authors. The works of many of these writers reflect the political, religious, and social issues of the twentieth century. New psychological insights run parallel with experiments in the use of myth, stream of consciousness, and symbolism. Authors studied may include Hardy, Conrad, Owen, Joyce, Lawrence, Woolf, Eliot, Yeats, and Orwell.

This course will be offered in 2011-12 and in alternating years thereafter.

EN 2251. MORAL ISSUES IN THE MODERN NOVEL.  Cat. I
This course focuses on the problem of how to live in the modern world. Emphasis will be placed on the way moral issues evolve within the complications of individual lives, as depicted in fiction. Such authors as Conrad, Keesey, Carse and Ellison show characters struggling with the questions of moral responsibility raised by love, religion, death, money, conformity.

EN 2252. SCIENCE AND SCIENTISTS IN MODERN LITERATURE.  Cat. I
This course surveys the ways in which modern literature has represented science and scientists. Beginning with Mary Shelley's Frankenstein, the origin of what Isaac Asimov calls the "damned Frankenstein complex" is examined. More complex presentations of science and scientists occur in twentieth-century works like Brecht's Galileo, Huxley's Brave New World, and Pirsaig's Zen and the Art of Motorcycle Maintenance.

The course covers major modern works of fiction and drama, including such literary forms as the play, the novel of ideas, and the utopian novel. Attention is focused on the themes (ideas) in, and the structure of, these works.
EN 3231. NEW ENGLAND SUPERNATURALISM.
Cat. II
From the colonial period to the 20th century, New England writers have endowed the region’s people and its settings (fields, forests, buildings, factories, cities) with shapes of fear. This course will explore New England’s fascination with the supernatural from Puritan writings to the contemporary tale of terror. A primary focus of the course will be the genre of New England Gothic and its literary conventions. Authors studied may include Hawthorne, Longfellow, Whitman, Alcott, and Louisa May Alcott to explore matters of cultural background, biography, contemporary events, uses of the past, literary vocation, and sense of place. Emphasis is on these writers’ friendships and their creative responses to intellectual and social forces of the day—factors that made Concord a community of highly individualistic writers.
This course will be offered in 2011-12 and in alternating years thereafter.
EN 3232. THE CONCORD WRITERS.
Cat. II
Rural, mid-19th-century Concord, Massachusetts, witnessed an unprecedented flowering of important and influential American literature. Why Concord? We sample writings of Ralph Waldo Emerson, Henry D. Thoreau, Nathaniel Hawthorne, Bronson Alcott, and Louisa May Alcott to explore matters of cultural background, biography, contemporary events, uses of the past, literary vocation, and sense of place. Emphasis is on these writers’ friendships and their creative responses to intellectual and social forces of the day—factors that made Concord a community of highly individualistic writers.
This course will be offered in 2011-12 and in alternating years thereafter.
Students who have received credit for EN 2236 (New England Writers: Concord) may not receive credit for EN 3232.
EN 3233. WORCESTER BETWEEN THE COVERS: LOCAL WRITERS AND THEIR WORKS.
Cat. II
Worcester has had a rich and varied literary history from Isaiah Thomas’s founding of the American Antiquarian Society in the early 1800s to the works of S. N. Behrman, Robert Benchley, Elizabeth Bishop, Esther Forbes, Stanley Kunitz, and Charles Olson in the 20th century. This course will examine selections from Worcester area writers in a number of genres (e.g., fiction, drama, poetry, essay, nonfiction memoir). Attention will be given to the local contexts of these writings as well as to each writer’s contributions to the larger continuum of American Literature.
This course will be offered in 2012-13 and in alternating years thereafter.
Students who have received credit for EN 2236 (New England Writers: Worcester) may not receive credit for EN 3233.
EN 3234. MODERN AMERICAN POETRY.
Cat. II
This course examines the poetries and poetics of various modern and contemporary American traditions, focusing on schools and styles from the Modernists and Objectivists through the Black Arts Movement, Confessional Poetry, the New York School, and the San Francisco Renaissance. Attention will also be given to recent innovations in digital poetry, multiethnic poetry, and performative poetry. The course will include poets such as Wallace Stevens, Gwendolyn Brooks, Elizabeth Bishop, A.R. Ammons, Joy Harjo, Jimmy Santiago Baca, Myung Mi Kim, and Saul Williams.
This course will be offered in 2012-13 and in alternating years thereafter.
EN 3237. PURSUING MOBY-DICK.
Cat. II
Since 1851, readers of Herman Melville’s masterpiece have joined in the chase for the “meaning” of the White Whale. After briefly examining the philosophical context of Emersonian idealism and the literary example of Hawthorne, the course is devoted solely to a close reading of Moby-Dick—one of the most innovative and mysterious novels in the English language. “Whose” book is it, anyway? Captain Ahab’s? Ishmael’s? The Whale’s? The reader’s? We conclude by surveying major critical approaches to the novel.
This course will be offered in 2012-13 and in alternating years thereafter.
EN 3248. THE ENGLISH NOVEL.
Cat. I
Participants in this seminar will examine the English novel from its origins in the eighteenth century to its twentieth-century forms, exploring the rich variety of ways a writer may communicate a personal and social vision. The novels may treat love, travel, humor, work, adventure, madness, and self-discovery; the novelists may include Fielding, Austen, Dickens, Eliot, Wodehouse, and Woolf.
EN ----. DRAMA/THEATRE PERFORMANCES.
TH: ISP
One-sixth unit of credit will be awarded at the conclusion of two successive terms of participation. Performance activities currently receiving credit are:
TH 1225 Theatre Production Practicum
TH 1227 Advanced Acting
TH 2227 Advanced Theatre Production Practicum
TH 3225 Directing
TH 3227 Advanced Directing
TH 3229 Dramaturgy
TH 4225 Theatre Technology Design
TH 4227 Advanced Theatre Technology Design
TH 4229 Advanced Dramaturgy
Credit would be given on the condition that the performance takes place in a WPI performance directed or advised by a part- or full-time WPI instructor.
Note: A maximum of two one-sixth units, or a total of one-third unit, may be applied toward the five courses, or five one-third units, taken prior to the final Humanities and Arts practicum.
ISE 1811. WRITING FOR NON-NATIVE SPEAKERS OF ENGLISH.
Cat. I
This course offers, through conferences, tutorial sessions and extensive writing practice, a review of English composition principles for international students. The following topics are included: the motivation of the writer; basic grammar; organization of the paragraph, sentence, and overall essay or report; vocabulary and word choice; spelling hints; and style. Much emphasis is given to the development of effective revising techniques.
ISE 1812. SPEECH FOR NON-NATIVE SPEAKERS OF ENGLISH.
Cat. I
This course focuses on developing international students’ ability to speak effectively, organize ideas logically, improve voice and diction, and use visual aids. Television and audiotapecs are used to record competence and poise.

GERMAN (GN)

GN 1511. ELEMENTARY GERMAN I.
Cat. I
An intensive language course designed to teach concise expression of ideas in writing and speaking. Basic grammar and significant cultural aspects are introduced through the aid of readings, audio-recordings, video, and oral group interaction. (Formerly GN 2616.)

GN 1512. ELEMENTARY GERMAN II.
Cat. I
A continuation of Elementary German I. Recommended background: GN 1511.

GN 2511. INTERMEDIATE GERMAN I.
Cat. I
A continuation of Elementary German II, with increased emphasis on oral and written expression. Basic textbook is supplemented by a collection of simple literary texts by the Grimm brothers, Brecht, and Bichsel. Recommended background: Elementary German II.

GN 2512. INTERMEDIATE GERMAN II.
Cat. I
A continuation of Intermediate German I. Recommended background: GN 2511.

GN 3511. ADVANCED GERMAN I.
Cat. I
Reading and in-class discussion of a wide variety of contemporary nonfictional and fictional texts. Some video viewing. Weekly brief writing assignments and continued expansion of vocabulary. Weekly vocabulary quiz. Review of grammar and introduction to advanced stylistic problems. Recommended background: Intermediate German II.

GN 3512. ADVANCED GERMAN II.
Cat. I
A continuation of Advanced German I. Recommended background: GN 3511. This course satisfies the Inquiry Practicum requirement.
GN 3513. SURVEY OF GERMAN CIVILIZATION AND CULTURE FROM 1871 TO THE PRESENT.
Cat. II
Conducted entirely in German, the course presents an overview of the development of modern Germany and its culture since the founding of the Second Empire. Background readings in German and English provide the basis for in-class discussion of selected authentic German texts of various kinds: literary works, official documents, political manifestos, letters, and diaries. At least one film will be shown. A number of recurring themes in German culture will inform the content of the course: authoritarianism versus liberalism, idealism versus practicality, private versus public life.
This course will be offered in 2012-13 and in alternating years thereafter.
Recommended background: GN 3511 (Advanced German I) and GN 3512 (Advanced German II) or equivalent.
This course satisfies the Inquiry Practicum requirement.

GN 3514. SEMINAR ON SELECTED TOPICS IN GERMAN LITERATURE.
Cat. II
The content of the seminar will change from time to time. The course will focus either on an author (e.g., Goethe, Heine, Kafka, Gunter Grass, Christa Wolf), a genre (e.g., lyric poetry, drama, narrative prose), a literary movement (e.g., Romanticism, expressionism), or a particular literary problem (e.g., literature and technology, writing and the Holocaust, writing and the city). The seminar will be conducted entirely in German.
The course will be offered in 2011-12 and in alternating years thereafter.
Recommended background: GN 3511 (Advanced German I) and GN 3512 (Advanced German II) or equivalent.
This course satisfies the Inquiry Practicum requirement.

GN 3516. GERMAN FILM.
Cat. II
Since its beginnings in the early 20th century, film has been a powerful medium for popular entertainment as well as a potent expression of society's dreams, fears, and values. Films made in the German-speaking countries are no exceptions, from early expressionist films like The Cabinet of Dr. Caligari through Nazi documentaries like Triumph of the Will to today's feature films such as Grizzly Man and Run Lola Run! Many German directors have achieved international renown. This course, conducted in German, will examine representative German-language films from various perspectives: historical, socio-political, and thematic. Films will be shown in German with English subtitles. The course will include weekly screenings, discussion sessions, and substantial written assignments.
Recommended background: GN3512 or higher.
This course will be offered in 2012-13 and in alternating years thereafter.

HISTORY (HI)

HI 1311. INTRODUCTION TO AMERICAN URBAN HISTORY.
Cat. I
An introduction to the history of the American city as an important phenomenon in itself and as a reflection of national history. The course will take an interdisciplinary approach to study the political, economic, social, and technological patterns that have shaped the growth of urbanization. In addition to reading historical approaches to the study of American urban history, students may also examine appropriate works by sociologists, economists, political scientists and city planners who provide historical perspective.

HI 1312. INTRODUCTION TO AMERICAN SOCIAL HISTORY.
Cat. I
An introduction to the historical study of American society. It addresses two questions: What is social history? and how do social historians work?

HI 1313. INTRODUCTION TO THE STUDY OF FOREIGN POLICY AND DIPLOMATIC HISTORY.
Cat. I
An introduction to the various components of U.S. foreign policy decision-making and the basic techniques of diplomatic history. The course will focus on one or two topics in the history of American foreign relations, using a variety of primary documents and secondary sources.

HI 1314. INTRODUCTION TO EARLY AMERICAN HISTORY.
Cat. I
An introduction to historical analysis through selected periods or themes in the history of America before the Civil War. A variety of readings will reflect the various ways that historians have attempted to understand the development of America.

HI 1321. INTRODUCTION TO EUROPEAN SOCIAL HISTORY.
Cat. I
An introduction to the study of modern European social history since the Industrial Revolution. Topics will include industrialization in Britain and Europe, class formation, gender and the condition of women, technology and economy, culture and society. Students will learn to work with historical sources, to formulate arguments, to read critically, and to write clearly.
No prior knowledge of European history is required.

HI 1322. INTRODUCTION TO EUROPEAN CULTURAL HISTORY.
Cat. I
In this course students think through some of the major intellectual currents that have defined modern Western Civilization. Topics include the philosophical impact of science on modern thought, the development of liberalism and socialism, the crisis of culture in the twentieth century. Students read selections from major thinkers in the Western tradition and develop their skills at critical thinking, analysis, oral and written argument.
No prior knowledge of European history is required.

HI 1331. INTRODUCTION TO THE HISTORY OF SCIENCE.
Cat. I
An introduction to the methods and source materials historians use to study the past, through the concentrated examination of selected case studies in the history of science. Possible topics include: contexts of scientific discovery, translation and transmission of scientific knowledge, revolutions in scientific belief and practice, non-Western science, social consequences of science.

HI 1332. INTRODUCTION TO THE HISTORY OF TECHNOLOGY.
Cat. I
An introduction to concepts of historical analysis — i.e., the nature and methodology of scholarly inquiry about the past — through the concentrated examination of selected case studies in the history of technology. Possible topics include: the influence of slavery on the development of technology in the ancient world and the middle ages; the power revolution of the middle ages; the causes of the Industrial Revolution in 18th-century Britain; and the emergence of science-based technology in 19th-century America.

HI 1341. INTRODUCTION TO GLOBAL HISTORY.
Cat. I
An introduction to the study of global history since 1500. Topics include global expansion, the Columbian exchange, and the slave trade; Renaissance, Reformation, and revolution in Europe; global industrialization, imperialism, and nation building; the world wars and revolutionary movements; decolonization and the Cold War. The course will also discuss case studies of developing nations of interest to students. Especially appropriate as background for students interested in International Studies or any of WPI's global Project Centers.

HI 2311. AMERICAN COLONIAL HISTORY.
Cat. I
This course surveys early American history up to the ratification of the Constitution. It considers the tragic interactions among Europeans, Indians, and Africans on the North American continent, the growth and development of English colonies, and the revolt against the Empire that culminated in the creation of the United States of America.

HI 2313. AMERICAN HISTORY, 1879-1877.
Cat. I
This course surveys American history from the Presidency of George Washington to the Civil War and its aftermath. Topics include the rise of American democracy, the emergence of middle-class culture, and the forces that pulled apart the Union and struggled to put it back together.

HI 2314. AMERICAN HISTORY, 1877-1920.
Cat. I
This course surveys the transformation of the United States into an urban and industrial nation. Topics will include changes in the organization of business and labor, immigration and the development of cities, the peripheral role of the South and West in the industrial economy, politics and government in the age of “laissez-faire,” and the diverse sources and nature of late 19th- and early 20th-century reform movements.

HI 2315. THE SHAPING OF POST-1920 AMERICA.
Cat. II
This course surveys the major political, social, and economic changes of American history from 1920 to the present. Emphasis will be placed on the Great Depression, the New Deal, suburbanization, McCarthyism, the persistence of poverty, the domestic effects of the Vietnam war, and recent demographic trends.
This course will be offered in 2012-13 and in alternating years thereafter.
HI 2316. AMERICAN FOREIGN POLICY FROM WOODROW WILSON TO THE PRESENT.
Cat. II
This survey of American diplomatic history begins with the legacy of Woodrow Wilson, continues through our apparent isolation in the 1920s, American neutrality in the 1930s, World War II, the early and later Cold War periods, and concludes with an overview of the current global involvement of the United States. This course will be offered in 2012-13 and in alternating years thereafter.

HI 2317. LAW AND SOCIETY IN AMERICA.
Cat. II
This survey course explores the dramatic expansion of government’s role in American life between the Civil War and World War I. It does so by examining the response of constitutional, common, and statutory law to the social, economic, and political change associated with this pivotal period in the nation’s history.

HI 2321. EUROPE FROM THE OLD REGIME TO WORLD WAR I.
Cat. I
A survey of the major socio-economic, political, and cultural developments in European history from the Old Regime to World War I. The course will focus upon those factors and events that led to the formation of modern European society: Nation-State building, The French Revolution, industrialization; liberalism, democracy, and socialism; national unification of Italy and Germany; the coming of World War I.
No prior knowledge of European history is required.

HI 2322. EUROPE SINCE WORLD WAR I.
Cat. I
A survey of the major political, socio-economic, and cultural developments in European history since World War I. The course will focus upon those factors and events that have led to the current world situation: the World Wars, fascism and communism, the Holocaust, the Cold War, the welfare state, decolonization, post-industrial society, popular culture, the collapse of communism, contemporary Europe.
No prior knowledge of European history is required.

HI 2324. INDUSTRY AND EMPIRE IN BRITISH HISTORY.
Cat. I
A survey of modern Britain from the 18th century to the present. Topics include the British state and national identity, the industrial revolution, political and social reform, the status of women, sport and society, Ireland, the British Empire, the World Wars, the welfare state, economic decline. Especially appropriate as background for students planning IQPs or Sufficiency Projects in London.
No prior knowledge of British history is required.

HI 2325. MODERN FRANCE.
Cat. II
This course examines the historical origins of modern France and the distinguishing features of French society and culture. Some of the topics covered include: Bourbon absolutism; the cause and effects of the French Revolution; the struggle for democratic liberalism in the 19th century; class and ideological conflict in the Third Republic; Vichy fascism, and present-day politics in the Fifth Republic.
No prior knowledge of French history is required.
This course will be offered in 2012-13 and in alternating years thereafter.

HI 2328. HISTORY OF REVOLUTIONS IN THE TWENTIETH CENTURY.
Cat. II
A survey of some of the most important revolutionary movements of the twentieth century. We may consider topics such as racial, nationalist, feminist and non-violent revolutionary ideologies, communist revolution, the “green” revolution and cultural revolution. No prior knowledge of the history of revolutions is expected.
This course will be offered in 2011-12 and in alternate years thereafter.

HI 2331. SCIENCE, TECHNOLOGY, AND CULTURE IN THE EARLY AMERICAN REPUBLIC.
Cat. II
This course surveys American science and technology from the first European explorations until the founding of WPI (in 1865). Topics may include: Enlightenment scientific theory and practice in colonial North America; Romanticism and the landscape; the politics of knowledge gained through contact with Native Americans; engineering and internal improvements; geography and resources in a continental empire; the American Industrial Revolution; the rise of science as a profession; the emergence of scientific racism; technology and the Civil War.
This course will be offered in 2012-13 and in alternating years thereafter.

HI 2332. HISTORY OF MODERN AMERICAN SCIENCE AND TECHNOLOGY.
Cat. I
This course surveys American science and technology from 1859 to the present. Topics may include: Darwinism and Social Darwinism; scientific education; positivism and the growth of the physical sciences; the new biology and medicine; conservation, the gospel of efficiency and progressivism; science, World War I and the 1920s; the intellectual migration and its influence; science technology and World War II; Big Science, the Cold War and responses to Big Science; and cultural responses to science and controversies about science.

HI 2341. CONTEMPORARY WORLD ISSUES IN HISTORICAL PERSPECTIVE.
Cat. II
This course examines the historical origins of contemporary global crises and political transformations. Students keep abreast of ongoing current events through periodical literature and explore the underlying long-term causes of these events as analyzed by scholarly historical texts. Topics will vary each time the course is taught but may include such topics as the following: The Israeli-Palestinian Conflict, Democratization in Africa, the Developing World and Globalization. No prior knowledge of world history is required.
This course will be offered in 2011-12 and in alternating years thereafter.

HI 2343. EAST ASIA: CHINA AT THE CENTER.
Cat. II
This course will explore two thousand years of Asian participation in an international system, in Asia and with the rest of the world. Whether ruled by Chinese, Turks, Mongols or Manchus, China has been the political and cultural center of East Asia. Understanding the role of this superpower is critical to Asian and world history. The course will focus on themes such as the cosmopolitan experience, the early development and application of ‘modern’ ideas such as bureaucracy, market economy, and paper currency, and the centrality of religious ideology as a tool in statecraft. No prior knowledge of Asian history is required.
This course will be offered in 2012-13, and in alternate years thereafter.

HI 2352. HISTORY OF THE EXACT SCIENCES.
Cat. II
This course surveys major developments in the global history of mathematics, astronomy, and cosmology, as manifestations of the human endeavor to understand our place in the universe. Topics may include: Ancient Greek, Ptolemaic, and Arabic knowledge systems; the Copernican Revolution; mathematical thinking and the Cartesian method; globalization of European power through the navigational sciences, applied mathematics, and Enlightenment geodesy; social consequences of probability and determinism in science; theoretical debates over the origins of the solar system and of the universe.
This course will be offered in 2011-12 and in alternating years thereafter.

HI 2353. HISTORY OF THE LIFE SCIENCES.
Cat. I
This course surveys major developments in the global history of biology, ecology, and medicine, as manifestations of the human endeavor to understand living organisms. Topics may include: Aristotelian biology, Galenic, Chinese, and Arabic medical traditions; Vesalius and the Renaissance; Linnaeus and Enlightenment natural history; Romantic biology and the Darwinian revolution; genetics from Mendel to the fruit fly; eugenics and racial theories as “applied” biology; modern medicine, disease, and public health; microbiology from the double helix to the Genome project; and the relationship of the science of ecology to evolving schools of environmental thought.

HI 2354. HISTORY OF THE PHYSICAL SCIENCES.
Cat. II
This course surveys major developments in the global history of geology, physics, and chemistry, as manifestations of the human endeavor to understand time, space, and the rules that govern inorganic nature. Topics may include: ancient atomism; alchemy and magic; the mechanical philosophy of Galilean and Newtonian physics; Hutton and the earth as eternal machine; energy, forces, matter, and structure in 19th century physics and chemistry; radioactivity, relativity, and quantum theory; the plate tectonics revolution.
This course will be offered in 2012-13 and in alternating years thereafter.
HI 2401. U.S. ENVIRONMENTAL HISTORY.
Cat. II
This course surveys the environmental history of North America from the time of Columbus until the present, exploring how the environment has shaped human culture, and how human activity and human ideas have shaped nature. We will examine changes during three periods: a "contact" period focusing on the ecological, economic and cultural ramifications of Old World-New World interconnection; a "development" period focusing on the rise of a market-based, urban-industrial society during the nineteenth century; and a final period characterized by the growth of reform movements to protect nature and the increasing global movement of goods and ideas in the twentieth century. In each period, we will trace changes in production, labor, and consumption patterns; transportation and other technologies; science, knowledge, and planning; disease, health and medicine; and cultural understandings, political debates, and place-making strategies.
This course will be offered in 2011-12 and in alternating years thereafter.

HI 2402. HISTORY OF EVOLUTIONARY THOUGHT.
Cat. II
This course will trace the history of evolutionary thought, including the growth of the geological sciences and expanding concepts of geological time, increased global travel suggesting new perspectives on biogeography, discoveries of fossils of now-extinct animals, and developments in comparative embryology and anatomy, culminating in the synthesis effected in 1859 by Charles Darwin, and in the Modern Synthesis of the 1940s. It will include emphases on the relationships of evolutionary and religious thought, and on depictions of evolutionary themes in the larger culture, including the arts, film, literature and popular culture, and will examine controversies, including current controversies, over evolution and the teaching of evolution in public schools in the United States.
This course will be offered in 2011-12 and in alternate years thereafter.

HI 3311. AMERICAN LABOR HISTORY.
Cat. I
This seminar course will deal with the history of organized labor in America as well as with the historic contributions of working people, whether unionized or not, to the growth and development of American ideas, politics, culture, and society. Among the topics to be covered will be: the origins, growth, and expansion of trade and industrial unionism; the roots and development of working class consciousness; the underlying causes and eventual resolution of labor disturbances; the philosophical and ideological perspectives of the labor movement. Students will explore topics raised by common readings via written papers, seminar presentations, and work with primary source materials.
Suggested background: HI 2314, American History, 1877-1920; or HI 2315, The Shaping of Post-1920 America.

HI 3312. TOPICS IN AMERICAN SOCIAL HISTORY.
Cat. I
A seminar course on analysis of selected aspects of social organization in American history, with emphasis on the composition and changing societal character of various groups over time, and their relationship to larger social, economic, and political developments. Typical topics include: communities, families, minorities, and women.
Suggested background: Some college-level American history.

HI 3314. THE AMERICAN REVOLUTION.
Cat. I
This seminar course considers the social, political, and intellectual history of the years surrounding American independence, paying particular attention to the changes in society and ideas that shaped the revolt against Great Britain, the winning of independence, and the creation of new political structures that led to the Constitution.

HI 3316. TOPICS IN TWENTIETH-CENTURY U.S. HISTORY.
Cat. II
In this advanced seminar course, students will explore one aspect of twentieth-century U.S. history in more depth. Topics vary each year but may include political movements such as the New Deal or the Civil Rights Movement, an aspect of American foreign policy such as the Cold War, a short time period such as the 1960s, a cultural phenomenon such as consumption, or a geographic focus such as cities or New England. The course will require substantial reading and writing. Suggested background: HI 2314 (American History, 1877-1920), HI 2315 (The Shaping of Post-1920 America), or other American history courses.
This course will be offered in 2011-12 and in alternating years thereafter.

HI 3317. TOPICS IN ENVIRONMENTAL HISTORY.
Cat. II
In this seminar course, students will explore one aspect of U.S. or global environmental history in more depth. Topics vary each year but may include environmental thought, environmental reform movements, comparative environmental movements, natural disasters, the history of ecology, built environments, environmental justice, New England environmental history, or the environmental history of South Asia or another region of the world. The course will require substantial reading and writing. Suggested background: HI 2401 U.S. Environmental History.
This course will be offered in 2012-13, and in alternating years thereafter.

HI 3321. TOPICS IN MODERN EUROPEAN HISTORY.
Cat. II
This seminar course examines topics in the cultural, socio-economic and political history of modern Europe, with a focus on Great Britain. Topics may vary each year among the following: nationalism, class and gender, political economy, environmental history, sport and society, film and history. Readings will include primary and secondary sources.
This course will be offered in 2011-12 and in alternating years thereafter.

HI 3323. TOPICS IN THE WESTERN INTELLECTUAL TRADITION.
Cat. II
This seminar course in the history of ideas focuses each year on a different theme within the intellectual-cultural traditions of Western Civilization. Some topics are the following: The Impact of the New Physics on 20th Century Philosophy; The Social History of Ideas; The Enlightenment and the French Revolution; Sexuality, Psycho-analysis, and Revolution. The course is structured around classroom discussion of major texts on the topic under study and a related research paper.
This course will be offered in 2011-12 and in alternating years thereafter.

HI 3331. TOPICS IN THE HISTORY OF EUROPEAN SCIENCE AND TECHNOLOGY.
Cat. II
A seminar course on the relationships among science, technology, and society in European culture, examined through a series of case studies. Topics from which the case studies might be drawn include: global scientific expeditions, mapmaking, and European imperialism; the harnessing of science for industrial purposes; the role of the physical sciences in war and international relations; the function of the science advisor in government; the political views and activities of major scientists such as Einstein. Students will use primary sources and recently published historical scholarship to analyze the case studies.
Suggested background: Courses in European history and the history of science and technology.
This course will be offered in 2012-13 and in alternating years thereafter.

HI 3334. TOPICS IN THE HISTORY OF AMERICAN SCIENCE AND TECHNOLOGY.
Cat. I
This seminar will examine a particular issue or theme in the history of American science and technology. Topics will vary from year to year, but may include: technology and the built environment; science, technology and the arts; communications of science and scientific issues with the larger public; technology and scientific illustration; science in popular culture; science and the law; or close examination of episodes in the history of American science and technology such as the American Industrial Revolution; science and technology in the years between the world wars; the Manhattan Project; science and the culture of the Cold War; or science, technology and war in American history. This course will require significant reading and writing.
Suggested background: Some familiarity with history of science or history of technology, and with United States history.

HI 3335. TOPICS IN THE HISTORY OF NON-WESTERN SCIENCE AND TECHNOLOGY.
Cat. II
A seminar course on the relationships among science, technology, and society from cultures outside Europe and North America, examined through a series of case studies. Topics from which the case studies might be drawn include: Chinese medicine and technology; Arabic mathematics, medicine, and astronomy; Indian science and technology (including, for example, metalworking and textile production); Mayan mathematics and astronomy; Polynesian navigation; various indigenous peoples’ sustainable subsistence technologies (e.g. African agriculture, Native American land management, aboriginal Australian dreamtime).
HUMANITIES AND ARTS COURSES

Suggested background: Courses in global history and the history of science and technology.

This course will be offered in 2011-12 and in alternating years thereafter.

HI 3341. TOPICS IN IMPERIAL AND POSTCOLONIAL HISTORY.
Cat. II
This seminar course examines topics in the history of European imperialism, colonialism, and the postcolonial aftermath. Topics vary each year among the following: culture and imperialism, the expansion of Europe, the economics of empire, travel and exploration narratives, imperialism in literature and anthropology, decolonization in Asia and Africa, postcolonial studies. Readings will include primary and secondary sources.

This course will be offered in 2012-13 and in alternating years thereafter.

HI 3342. TOPICS IN COMPARATIVE CIVILIZATIONS.
Cat. II
This seminar course compares and contrasts major religious, philosophical, social, and political themes in different civilizations. Comparisons will vary each year but may be drawn from Asia, the Indian subcontinent, the Middle East, Africa, and indigenous cultures of the Americas. It examines the historical foundations of these civilizational differences and draws comparisons with common features of Western civilization. One important goal of the course is to enhance student appreciation of non-Western values and traditions.

This course will be offered in 2012-13 and in alternating years thereafter.

HI 3343. TOPICS IN ASIAN HISTORY.
Cat. I
This seminar course examines topics in the cultural, socio-economic, religious and political history of East Asia. Topics vary each year and may include the following: nationalism and the writing of history, travel and exploration narratives, cross-cultural contact, the role of religion and ideology in political history, development and the environment in Asia, film and history, and the place of minorities and women in Asian societies. Suggested background: previous courses on Asia such as HU 1412, HI 2328, HI 2343, or RE 2724.

ISE 1813. AMERICAN HISTORY FOR INTERNATIONAL STUDENTS.
Cat. I
An introduction to American history designed to provide international students with a basic understanding of the history and culture of the United States. Written and oral assignments will also help these students gain a more effective command of the English language.

HUMANITIES (HU)
The courses listed below are general humanities courses and are intended to provide conceptual introductions to the major disciplines within the humanities. Students will encounter the basic methods of critical analysis and discussion required for the future investigation of the specific area they choose for their humanities and arts requirement. These courses emphasize patterns of thought, methods of inquiry, appropriate vocabulary, and critical attitudes needed to appreciate most fully various areas in the humanities; they are not intended as surveys or historical overviews. Consequently, in each course the subject matter used to develop and illustrate key concepts and approaches will change regularly. Practice in analytic thinking and writing will be a significant part of each course. The skills generated by these courses will greatly aid students in developing their themes and will be essential for the completion of the Humanities and Arts Requirement.

HU 1401. INTRODUCTION TO HUMANITIES AND ARTS I.
Cat. I
This course provides an introduction to the Humanities and Arts by examining, discussing, and communicating our ideas about a fundamental question in human experience: what is real and how are claims made for that reality? Students will study this question from the points of view of literature, history, science, and art.

HU 1402 is open to all students with preference given to first-year students, especially those who would like to sample several different areas of the Humanities and Arts before deciding on an area of concentration. HU 1402 follows historically from HU 1401 and students are encouraged BUT NOT REQUIRED to take both courses.

HU 1402. INTRODUCTION TO HUMANITIES AND ARTS II.
Cat. I
This course provides an introduction to the Humanities and Arts by examining, discussing, and communicating our ideas about a fundamental question in human experience: what is real and how are claims made for that reality? Students will study this question from the points of view of literature, history, science, and art.

HU 1402 is open to all students with preference given to first-year students, especially those who would like to sample several different areas of the Humanities and Arts before deciding on an area of concentration. HU 1402 follows historically from HU 1401 and students are encouraged BUT NOT REQUIRED to take both courses.

HU 1411. INTRODUCTION TO AMERICAN STUDIES.
Cat. II
This interdisciplinary course introduces students to a number of basic American Studies methodologies. Emphasis will vary according to the instructor, but usually the course will cover the following: the textual and contextual analysis (at the community, national, and transnational levels) of literary works; the relationships between the literary, performing, and visual arts in a specific time period; the analysis of radio, film, television, and digital media forms at the level of production and reception; the mediation and remediation of cultural, social, and political history.

This course will be offered in 2011-12 and in alternating years thereafter.

HU 1412. INTRODUCTION TO ASIA.
Cat. II
This course will explore Asia through an interdisciplinary approach. We will examine tradition and modernity in some or all of four cultural regions—South Asia (India), East Asia (China), Southeast Asia (Vietnam or Thailand), Inner Asia (Tibet)—and globalization in Japan and/or Hong Kong. We will explore the cultural traditions of these various regions, paying special attention to history, religion, society. We will also consider modern developments in these same regions. The impact of colonialism, nationalism, revolution, industrialization and urbanization on the lives of Asian peoples will be illustrated through films and readings. No prior knowledge of Asian history or culture is expected.

HU 2441. AFRICAN HISTORY AND CULTURE.
Cat. I
This seminar course examines topics in the history of European imperialism, and technology.

This seminar will explore Africa through an interdisciplinary approach. We will examine tradition and modernity in some or all of four cultural regions—South Asia (India), East Asia (China), Southeast Asia (Vietnam or Thailand), Inner Asia (Tibet)—and globalization in Japan and/or Hong Kong. We will explore the cultural traditions of these various regions, paying special attention to history, religion, society. We will also consider modern developments in these same regions. The impact of colonialism, nationalism, revolution, industrialization and urbanization on the lives of Asian peoples will be illustrated through films and readings. No prior knowledge of European history or culture is expected.

HU 2441. AFRICAN HISTORY AND CULTURE.
Cat. II
This course will examine the fundamentals of intercultural communication to prepare students to live and work with people from other cultures. It explores how different patterns of thinking and behavior, assumptions and values, have arisen from different cultural traditions and divergent histories in the world. Racism, prejudice, and bigotry—often the result of cultural, social, and technological differences in human experience—are among the concerns of the class. This course cannot teach students how to behave and think in all parts of the world, but it raises questions about ethnocentric assumptions often taken for granted by those working or studying in another culture. It is excellent preparation for an international IQP or educational exchange.

Suggested background: Previous courses in Humanities.

This course will be offered in 2011-12 and in alternating years thereafter.

HU 3411. PRO-SEMINAR IN GLOBAL PERSPECTIVES.
Cat. II
This course examines the fundamentals of intercultural communication to prepare students to live and work with people from other cultures. It explores how different patterns of thinking and behavior, assumptions and values, have arisen from different cultural traditions and divergent histories in the world. Racism, prejudice, and bigotry—often the result of cultural, social, and technological differences in human experience—are among the concerns of the class. This course cannot teach students how to behave and think in all parts of the world, but it raises questions about ethnocentric assumptions often taken for granted by those working or studying in another culture. It is excellent preparation for an international IQP or educational exchange.

Suggested background: Previous courses in Humanities.

This course will be offered in 2011-12 and in alternating years thereafter.

HU 3900. INQUIRY SEMINAR IN HUMANITIES AND ARTS.
Cat. I
This seminar serves as the culmination for a student’s Humanities and Arts Requirement. The seminar provides opportunities for sustained critical inquiry into a focused thematic area. The seminar seeks to help students learn to communicate effectively, to think critically, and to appreciate diverse perspectives in a spirit of openness and cooperation through research, creativity, and investigation. The specific theme of each seminar will vary and will be defined by the instructor. Prior to enrolling in the seminar, a student must have completed five courses in Humanities and Arts, at least two of which must be thematically related and at least one of which must be at the 2000-level or above.

HU 3910. PRACTICUM IN HUMANITIES AND ARTS.
Cat. I
The practicum serves as the culmination for a student’s Humanities and Arts Requirement. The practicum provides opportunities for sustained critical inquiry into a focused thematic area. The practicum seeks to help students learn
to communicate effectively, to think critically, and to appreciate diverse perspectives in a spirit of openness and cooperation through research, creativity, and investigation. The specific theme of each practicum will vary and will be defined by the instructor. Prior to enrolling in the practicum, a student must have completed five courses in Humanities and Arts, at least two of which must be thematically related and at least one of which must be at the 2000-level or above. Consent of the instructor is required for enrollment.

**MU 4411. SENIOR SEMINAR IN INTERNATIONAL STUDIES.**
*Cat. I*
This course is designed to integrate each student’s international courses, projects, and experiences in a capstone seminar in International Studies. Students will reflect on what they have learned in their previous courses and international experiences. They will assess what happened to them overseas, why it happened, and how it might be understood. They will also prepare a paper with an instructor in their area of international studies that integrates their previous academic courses. Students will also explore how they might translate their courses and experiences into future personal and professional opportunities.

Recommended background: previous courses in international studies, such as HI 1341 and HU 3411, and completion of an international IQP or an international educational exchange.

**HU—AAS-50. AMERICAN ANTIQUARIAN SEMINAR.**
*ISP*
Each fall the American Antiquarian Society and five Worcester colleges sponsor a research seminar at the Antiquarian Society library. The seminar is conducted by a scholar familiar with the Society’s holdings in early American history, and the seminar topic is related to his or her field of research.

Selection is highly competitive. The ten participating students are chosen by a screening committee made up of representatives of the five participating colleges: Assumption College, Clark University, College of the Holy Cross, WPI, and Worcester State College.

The seminar topic and research methods combine several disciplines, and students from a wide variety of majors have participated successfully in this unique undergraduate opportunity.

**MUSIC (MU)**

**MU 1611. FUNDAMENTALS OF MUSIC I.**
*Cat. I*
This course concentrates on basic music theory of the common practice period. If time permits, instruction includes ear training, sight singing, and work on scales and intervals.

Recommended background: basic knowledge of reading music.

**MU 2611. FUNDAMENTALS OF MUSIC II.**
*Cat. I*
Fundamentals II is a course on music theory at the advanced level beginning with secondary dominants and modulations and working through 19th-century chromatic harmony.

**MU 2719. JAZZ HISTORY.**
*Cat. II*
Through an introduction to the musical contributions of Louis Armstrong, Duke Ellington, Charlie Parker, Miles Davis and others, students are exposed to the chronological development of the language of jazz. Each jazz era is examined in detail including the musical and social contexts which helped define it. Participants are expected to build aural skills with the goal of identifying specific historical periods through the recognition of particular musical characteristics. Students examine in depth one artist of their choice.

This course will be offered in 2012-13 and alternating years thereafter. [This replaces MU 4623. Credit is not allowed for both MU 4623 and MU 2719.]

**MU 2720. MUSIC HISTORY I: MEDIEVAL THROUGH THE BAROQUE.**
*Cat. II*
This course provides a historical survey of Western music from Medieval through Baroque periods with an emphasis on understanding stylistic traits and theoretical concepts of the eras. Topics include Gregorian chant and secular monophony; evolution of musical notation; development of polyphonic music; and vocal and instrumental genres such as mass, motet, madrigal, opera, cantata, sonata, and concerto, among others.

No prior background in music is necessary.

This course will be offered in 2012-13 and alternating years thereafter.

**MU 2721. MUSIC HISTORY II: CLASSICAL TO THE PRESENT.**
*Cat. I*
This course provides a historical survey of Western music from the Classical period to the present with an emphasis on understanding stylistic traits and theoretical concepts of the eras. Topics include the development of genres such as sonata, string quartet, concerto, symphony, symphonic poem, character piece, Lied, and opera; and 20th-century trends of impressionism, primitivism, atonality, serialism, minimalism, aleatory music, and electronic music.

No prior background in music is necessary.

**MU 2722. HISTORY OF AMERICAN POPULAR MUSIC.**
*Cat. I*
This course will explore the uniqueness of America’s popular music and its origins in the music of Africa and the folk music of Europe. Particular emphasis will be given to the origins and history of rock ‘n’ roll examining its roots in blues and early American popular music. [This replaces MU 4625. Credit is not allowed for both MU 4625 and MU 2722.]

**MU 2723. MUSIC COMPOSITION.**
*Cat. I*
This course will investigate the sonic organization of musical works and performances, focusing on fundamental questions of unity and variety. Using a progressive series of composition projects, the class will examine aesthetic issues that are considered in the pragmatic context of the instructions that composers provide to achieve a desired musical result. The class will examine the medium of presentation - whether these instructions are notated in prose, as graphic images, or in symbolic notation. Weekly listening, reading, and composition assignments draw on a broad range of musical styles and intellectual traditions, from various cultures and historical periods.

The class will meet for two weekly sessions of one hour and fifty minutes. Each student will be assigned a performance ensemble. Each performance ensemble will have a weekly two-hour lab. In addition, each student will keep a weekly log (online) of his or her experiences as a composer.

**MU 2730. JAZZ THEORY.**
*Cat. I*
This course examines harmonic and melodic relationships as applied to jazz and popular music composition. Students are introduced to a wide range of jazz improvisational performance practices. Topics include compositional forms, harmonic structures, major and minor keys, blues, modal jazz, and reharmonization techniques. Students are expected to have a basic knowledge of reading music. [This replaces MU 4624. Credit is not allowed for both MU 4624 and MU 2730.]

**MU 3001. WORLD MUSIC.**
*Cat. II*
This course introduces students to selected musical cultures of the world, e.g., Africa, Asia, the Middle East, and Latin America, from the ethnomusicological perspective by examining their musical styles as well as cultural and social contexts. Students will be expected to read materials in interdisciplinary areas, including musical ethnographies.

No prior background in music is necessary.

This course will be offered in 2011-12 and alternating years thereafter.

**MU 3002. ARRANGING AND ORCHESTRATION.**
*Cat. I*
Students will study specific characteristics of instruments and the voice to enable them to successfully arrange vocal and instrumental music. Students will need to possess a basic knowledge of music theory. Suggested background for this course is MU 1611 (Fundamentals of Music I) or its equivalent.

**MU 3611. COMPUTER TECHNIQUES IN MUSIC.**
*Cat. I*
This course concentrates on both the technical and artistic aspects of computer music. Topics covered include the MIDI protocol and specification, sequencer design, voice editing, synthesizer architecture, and literature.

**MU 3612. COMPUTERS AND SYNTHESIZERS IN MUSIC.**
*Cat. I*
This course focuses on technical and aesthetic problem solving in computer music. Using programming languages, students propose and design creative solutions to contemporary problems which currently have no commercial solutions. Students work with sequencers, signal processors, synthesizers, MIDI controllers, editors, and programming languages.
MU 2631. DIGITAL SOUND DESIGN.
Cat. I
This course introduces the student to the theory and practice of digital sound design. It focuses on creative problem-solving in applications where digital audio production is a key component. Topics include digital sound recording and editing, creation and synchronization of digital sound tracks for video, theatrical sound design, and multimedia production.

MU 4621. INDEPENDENT INSTRUCTION (LESSONS) IN MUSIC.
ISP
Students electing to complete their Humanities and Arts Requirement in music may, for one of their five courses, undertake 1/3 unit (normally at 1/12 unit per term) of private vocal or instrumental instruction. (Supplemental ensemble work is also strongly recommended.) The student must receive prior approval by a member of the WPI music faculty, and the instruction must be beyond the elementary level. Lessons involve a separate fee. Note that the maximum of 1/3 unit credit for lessons may be earned in addition to 1/3 unit credit for performance (see condition A or B below). Additional work, either in performance or lessons, may be acknowledged on the WPI transcript but will carry no WPI credit. Private lessons: voice, piano, organ, winds, brass, strings, and percussion.

MU 4628. PERFORMANCE SUFFICIENCY.
ISP
A practicum in music may be fulfilled by a recital performance in addition to a related paper, provided the music faculty determines that the student's capabilities be of a high order. During this term, the student usually is under private instruction, the cost of which is borne by the student.

NOTE: Two 1/3 units credit remain the maximum allowed for all lessons and performance credit.

MUSIC ENSEMBLES (MU)

Students who sing or play a traditional band or orchestra instrument at the intermediate level or better may enroll for any of the ensembles listed below. Students will register at the beginning of A term and receive 1/6 unit at the end of B term for participation in both terms. Students may also register at the beginning of C term and receive 1/6 unit at the end of D term for participation in both terms. Students may apply up to 1/3 unit of performing ensembles to the Humanities and Arts Sufficiency course requirement.

MU 2631. MEN'S GLEE CLUB.
Cat. I
The Glee Club is the men's choral ensemble and the oldest student organization on campus. Glee Club performs many styles and periods of the vast repertoire of music for men's ensembles. Several times each year the Glee Club and Alden Voices (Women's Chorale) joint forces as the WPI Festival Chorus to perform major works of the repertoire. The Glee Club tours Europe and also performs on tour. Rehearsals are held weekly. Prior singing or music experience is encouraged but not required. Open to all men.

MU 2632. ALDEN VOICES.
Cat. I
Alden Voices is the women's choral ensemble. Alden Voices performs many styles and periods of the vast repertoire of music for women's ensembles. Several times each year Alden Voices and the Men's Glee Club joint forces as the WPI Festival Chorus to perform major works of the repertoire. Alden Voices performs on tour as well as performing on campus. Rehearsals are held weekly. Prior singing or music experience is encouraged but not required. Open to all women.

MU 2633. BRASS ENSEMBLE.
Cat. I
The Brass Ensemble performs frequently on campus and on tour and is open to students who perform on trumpet, trombone, euphonium, French horn, tuba, or tympani. Renaissance antiphonal music is included in the repertoire. Rehearsals are held weekly. Students are expected to perform with the ensemble and to know how to read music. Permission of the instructor is necessary to register.

MU 2634. JAZZ ENSEMBLE.
Cat. I
The Jazz Ensemble performs frequently on campus and on tour and plays jazz arrangements written for a small ensemble with major emphasis on improvisation. Rehearsals are held weekly. Students are expected to perform with the ensemble and to know how to read music. Permission of the instructor is necessary to register.

MU 2635. STAGE BAND.
Cat. I
The Stage Band performs traditional and contemporary big band literature with an emphasis on stylistically appropriate interpretation and performance practice. The ensemble performs frequently on campus and on tour. Rehearsals are held weekly. Students are expected to perform with the ensemble and to know how to read music. Permission of the instructor is necessary to register.

MU 2636. CONCERT BAND.
Cat. I
The Concert Band is a large ensemble that performs several concerts a year as well as on tour. Membership is open to those who play traditional wind, brass or percussion instruments. Rehearsals are held weekly. Students are expected to perform with the ensemble and to know how to read music.

MU 2637. STRING ENSEMBLE.
Cat. I
The String Ensemble performs music for string orchestra both on campus and on tour. Members of the string ensemble also comprise the string section for the full orchestra. Rehearsals are held weekly. Students are expected to perform with the ensemble and to know how to read music.

MU 2638. VOCAL PERFORMANCE LAB.
Cat. I
The Vocal Performance Lab is a performance practice oriented chamber vocal ensemble. This ensemble explores specific stylistic techniques as pertains to the music of the Renaissance, Baroque, twentieth century, jazz, and extended vocal techniques (electronic, digital and experimental). The ensemble meets weekly. Students are expected to be of the highest vocal caliber and should possess advanced sight-reading techniques. Open to both men and women. Permission of the instructor is necessary to register.

PHILOSOPHY (PY)

PY/RE 1731. INTRODUCTION TO PHILOSOPHY AND RELIGION.
Cat. I
This course provides an overview of key concepts, methods and authors in both fields. These introduce the student to the types of reasoning required for the pursuit of in-depth analysis in each discipline. Emphasis on topics and authors varies with the particular instructor.

PY 2711. PHILOSOPHICAL THEORIES OF KNOWLEDGE AND REALITY.
Cat. I
This course introduces students to methods of philosophical analysis relating to the classification and conceptualization of entities and the nature of knowledge. The course will focus on a related set of problems or on the elaboration of a philosophical issue of knowledge or reality in the history of philosophy. Among themes and problems considered might be: How has the being of nature and knowledge of nature been represented in Western philosophy and science? What kind of a phenomenon is mind or thought and can entities in addition to human beings, such as computers, be said to have this attribute? What are reliable methods of arriving at and evaluating scientific knowledge, and are these methods identical for the natural and human sciences? Readings might include excerpts from the works of Plato, Aristotle, Bacon, Descartes, Kant, James, Dewey and Heidegger, as well as numerous contemporary philosophers.
Suggested background: familiarity with basic philosophical concepts and terms (as in PY/RE 1731).

PY 2712. SOCIAL AND POLITICAL PHILOSOPHY.
Cat. II
This course examines metaphysical and moral questions that philosophers have raised about social and political life. Among questions treated might be: What are the grounds, if any, of the obligation of a citizen to obey a sovereign? Are there basic principles of justice by which societies, institutions and practices are rightly evaluated? What is democracy, and how can we tell if an institution or practice is democratic? To what degree do economic institutions put limits on the realization of freedom, democracy and self-determination? Readings might include excerpts from the works of Plato, Hobbes, Locke, Rousseau and Marx, as well as numerous contemporary philosophers.
Suggested background: familiarity with basic concepts in philosophy (as in PY/RE 1731).

This course will be offered in 2011-12 and in alternative years thereafter.
PY 2713. BIOETHICS.  
Cat. II  
The purpose of this course is to evaluate the social impact of technology in the areas of biology/biotechnology, biomedical engineering and chemistry. The focus of the course will be on the human values in these areas and how they are affected by new technological developments. The course will deal with problems such as human experimentation, behavior control, death, genetic engineering and counseling, abortion, and the allocation of scarce medical resources. These problems will be examined through lectures, discussions and papers.  
Suggested background: knowledge of the medical fields and ethics.  
The purpose of this course is to expose students to somewhat more advanced and specialized study in philosophy. Its focus will vary, but will typically be one of the following types: a particular philosopher (e.g., Plato, Kant, Mill); a particular philosophical tradition (e.g., Pragmatism, Ordinary Language philosophy, Empiricism); a particular philosophical problem (free will, knowledge of other minds, historical explanation); or a particular philosophical classic (Hegel's *Phenomenology of Mind*, Aristotle's *Ethics*).  
Suggested background: three other philosophy courses.  
PY 2714. ETHICS AND THE PROFESSIONS: PERSONAL, PROFESSIONAL, AND SOCIAL DILEMMAS.  
Cat. II  
This course will present a framework by which various ethical dilemmas that arise in the professions, especially the science-related professions, can be identified, examined, and evaluated at the level of personal morality, professional codes of ethics, and social values. The goal is to study the solutions of these dilemmas in each of the three levels to determine what relation there may be between them, and whether or not resolutions of a dilemma on one level are appropriate for another level. Ethical concepts, professional codes of ethics, and policy positions will be used to analyze and evaluate these issues in a case study format. Representatives of appropriate professions will be invited to address specific issues pertaining to ethical dilemmas in their field.  
This course will be offered in 2012-13 and in alternating years thereafter.

PY 2715. ETHICS AND RELIGION.  
Cat. II  
The course will attend to the social context in which these religions developed primarily on Judaism, Christianity and Islam. Other religions will be examined.  
The purpose of this course is to examine, from an historical, doctrinal, scriptural and practical perspective, major Western religions. The course will focus primarily on Judaism, Christianity and Islam. Other religions will be examined.  
Suggested background: three other philosophy courses.  
PY 2716. PHILOSOPHY OF DIFFERENCE.  
Cat. II  
This course examines philosophical presuppositions and questions of value underlying and expressed in the construction of masculinity and femininity in modern society. The course may also examine social identities rooted in race, ethnicity, sexual preference, and ability/disability. Possible topics include: changing conceptions of love, sex, marriage, and parenting; how our conceptions of masculinity and femininity are influenced by and influence (for example) religion, science, politics, work, and art; and the relations between feminist theory and other critical social theories.  
This course will be offered in 2012-13 and in alternating years thereafter.

PY 2717. PHILOSOPHY AND THE ENVIRONMENT.  
Cat. I  
This course will focus on the following questions:  
What is the scope of the current environmental crisis? What does this crisis reveal about the philosophical presuppositions and dominant values of our intellectual worldviews and social institutions? How can existing social theories help explain the environmental crisis? What implications does the crisis have for our sense of personal identity? What moral and spiritual resources can help us respond to it?  
Readings will be taken from contemporary and historical philosophers and naturalists.  
Suggested background: familiarity with basic concepts in philosophy (as in PY/RE 1731).  
PY 2718. FREEDOM AND EXISTENCE.  
Cat. I  
This course takes up the question of the relationship between self and other, the tension between freedom and responsibility, and the problem of ethical and political commitment in an alienating world. How is individuality possible in a world of egoism and apathy? How do we resolve the tension between freedom and responsibility?  
Suggested background: PY/RE 2731, Introduction to Philosophy and Religion.  
This course will be offered in 2011-12 and in alternating years thereafter.

PY/RE 2731. INTRODUCTORY ETHICS.  
Cat. I  
This course will review at an introductory level theories of ethics, individual figures in the history of ethics, and selected problems in ethics. The emphasis will be on philosophical or religious ethics depending on the instructor.
RE 2724. RELIGIONS OF THE EAST.

Cat. II

The purpose of this course is to examine, from the perspectives of history, text, practice, and philosophy, some or all of the following religions: Hinduism, Buddhism, Taoism, Confucianism, and Shinto. The course will attend to the social context in which these religions began, their relations with their culture, their rituals and their continuing influences in the East and West.

Suggested background: PY/RE 1731 and RE 2721.

This course will be offered in 2011-12 and in alternating years thereafter.

RE/PY 2731. INTRODUCTORY ETHICS.

Cat. I

This course will review at an introductory level theories of ethics, individual figures in the history of ethics, and selected problems in ethics. The emphasis will be on philosophical or religious ethics depending on the instructor.

RE 3721. TOPICS IN RELIGION.

Cat. I

The purpose of this course is to expose students to somewhat more advanced or specialized study in religion. The focus will vary, but the material will be drawn from a particular religious thinker, a particular religious tradition or a particular historical or contemporary problem.

Suggested background: three other courses in religion.

RE/PY 3731. PROBLEMS IN ETHICS AND SOCIAL PHILOSOPHY.

Cat. I

This course will examine in depth selected problems in ethical theory and social philosophy. The specific content or emphasis will be determined by the instructor.

Suggested background: knowledge of either RE/PY 2731 or PY 2712.

RHETORIC (RH) AND WRITING (WR)

RH 3111. THE STUDY OF WRITING.

Cat. I

This course introduces students to issues in the study of writing such as the history and uses of literacy, the relationship of thought to language, the role of writing in producing knowledge, and research on composing. The focus of the course will be on professional and academic writing. The course will be organized around a series of interrelated research questions: How do writers in professional and academic settings know when they have something to write about? How do they define a problem to investigate? How do they define or construct an audience to address? How do they locate their work in relation to others' work? How do they know which forms of writing to use? Why do they write in the first place? What functions does writing perform?

RH 3112. RHETORICAL THEORY.

Cat. I

Rhetoric concerns both the art of mastering the available means of persuasion and the study of how oral, written, and visual communication projects the intentions of individuals and groups, makes meanings, and affects audiences. The purpose of this course therefore is two-fold. It is intended to help students become more effective communicators by learning about the rhetorical situation and various rhetorical techniques, and it is designed to help them understand how various forms of communication work by learning some of the strategies of rhetorical analysis.

RH 3211. RHETORIC OF VISUAL DESIGN.

Cat. I

This course explores how visual design is used for purposes of identification, information, and persuasion. It looks at many modes of visual communication, such as icons, logos, trademarks, signs, product packaging, infographics, posters, billboards, ads, exhibits, graffiti, page layout, films, television, videogames, and web sites. The course provides an overview of the history of graphic design movements, as well as analytical tools to understand how visual design encodes messages and the role visual communication plays in contemporary culture.

EN/WR 2210. INTRODUCTION TO PROFESSIONAL WRITING.

Cat. I

This course will serve as a gateway into the Professional Writing major but will also be open—and useful—to any student interested in learning about the standard written genres of professional, workplace communication. Students will analyze the history, purposes, conventions, and social consequences of a variety of professional communication, focusing on digital and print correspondence, reports, and proposals directed to internal and external audiences. Students will learn about the culture of a professional environment and the role of writing in structuring identity and relationships within that context. Classes will be conducted as interactive writing workshops in which students assess and respond to rhetorical scenarios and sample texts from a variety of professional worksites. Students will create portfolios, producing professional writing samples they may use on the job market.

WR/EN 2211. ELEMENTS OF WRITING.

Cat. I

This course is designed for students who wish to work intensively on their writing. The course will emphasize the processes of composing and revising, the rhetorical strategies of written exposition and argumentation, and the reading and citation practices central to academic inquiry. In a workshop setting, students will write a sequence of short papers and complete one longer writing project based on multiple source texts; learn to read critically and respond helpfully to each other's writing; and make oral presentations from written texts. Where applicable, the topical theme of the class will be provided via the Registrar's office.

EN/WR 2213. INTRODUCTION TO JOURNALISM.

Cat. I

The course is for students who may wish to make careers in journalism or communications and for those who wish to understand the history, function, production, and contemporary challenges of print journalism. Students will analyze articles from newspapers, magazines and Web sites. They will learn and practice the skills of the journalist: finding the story, researching, interviewing, writing on deadline, copy-editing and proof-reading. Classes will also cover matters such as objectivity, fairness, ethics and libel, as well as wider issues of mass communication such as agenda setting, citizen journalism and the implications of converging media. To give students a more keen sense of audience, work will be read and discussed in class. Students will be urged to write for the college newspaper. Publication beyond the campus will be strongly encouraged.

WR/EN 3011. PEER TUTORING IN WRITING.

Cat. I

Peer Tutoring in Writing introduced students to the theory and practice of composition. In this course, students research, read, and write about their own and others' literacy practices. Through reading and writing assignments, peer reviews, interviews, presentations, and a tutoring internship in the CCAC, students hone their communication skills while increasing their ability to examine critically the role of communication in the production of knowledge.

EN/WR 3210. TECHNICAL WRITING.

Cat. I

Technical writing combines technical knowledge with writing skills to communicate technology to the world. This course introduces the fundamental principles of technical communication, and the tools commonly used in the technical writing profession. Topics include user and task analysis, information design, instructional writing, and usability testing. Students learn to use the technical writing process to create user-centered documents that combine text, graphics, and visual formatting to meet specific information needs. Students create a portfolio of both hardcopy and online documentation, using professional tools such as FrameMaker, Acrobat, and RoboHelp.

Recommended background: EN/WR 2210, or equivalent writing course.

WR/EN 3214. WRITING ABOUT DISEASE AND PUBLIC HEALTH.

Cat. I

This writing workshop focuses on the purposes and genres of writing about disease and public health. We will consider how biomedical writers communicate technical information about disease and public health to general audiences; how writers treat the public policy implications of disease; and how writers design publicity to promote public health. We will examine such genres as the experimental article, news reports, medical advice, profiles, commentary, and public health messages.

Recommended background: EN 3211 or equivalent writing courses. Students who have taken EN 3215 may not receive credit also for WR/EN 3214.

WR/EN 3217. CREATIVE WRITING.

Cat. I

The purpose of this course is to help students develop or improve the skills of written expression. Small groups are formed in which participants present and discuss their original work in either fiction or poetry.
SPANISH (SP)

SP 1523. ELEMENTARY SPANISH I.
Cat. I
A very intensive course that will introduce the student to the basic grammar of Spanish, emphasizing the four language skills: listening, speaking, reading and writing. It will also introduce the student to different aspects of Hispanic cultures in the U.S. and in Spanish-speaking countries. Students who have taken Spanish in high school are urged to take a placement exam before enrolling in either level of Elementary Spanish.

To enroll in this course, you must obtain written permission from one of the Spanish professors. This course is reserved for those students with only one year of high school Spanish or with no previous experience. This course is closed to native speakers of Spanish and heritage speakers except with written permission from the instructor.

SP 1524. ELEMENTARY SPANISH II.
Cat. I
A continuation of Elementary Spanish I.
Recommended background: SP 1523.
This course is closed to native speakers of Spanish and heritage speakers except with written permission from the instructor.

SP 2521. INTERMEDIATE SPANISH I.
Cat. I
A course designed to allow students to improve their written and oral skills, expand their vocabulary and review some important grammatical structures. Students will also read short stories and poems by some of the most representative Spanish American and Spanish authors, such as Horacio Quiroga, Jorge Luis Borges, Gabriela Mistral and Ana María Matute.
Recommended background: Elementary Spanish II.
This course is closed to native speakers of Spanish and heritage speakers except with written permission from the instructor.

SP 2522. INTERMEDIATE SPANISH II.
Cat. I
A continuation of Intermediate Spanish I.
Recommended background: SP 2521.
This course is closed to native speakers of Spanish and heritage speakers except with written permission from the instructor.

SP 3521. ADVANCED SPANISH I.
Cat. I
A course that continues to improve students’ language skills while deepening their understanding of Hispanic cultures. Some of the topics studied are: the origins of Hispanic cultures in Spain and Spanish America; family; men and women in Hispanic societies; education; religion.
Recommended background: Intermediate Spanish II.
This course is closed to native speakers of Spanish and heritage speakers except with written permission from the instructor.

SP 3522. ADVANCED SPANISH II.
Cat. I
A continuation of Advanced Spanish I.
Recommended background: SP 3521.
This course satisfies the Inquiry Practicum requirement.
This course is closed to native speakers of Spanish except with written permission from the instructor.

SP 3523. TOPICS IN LATIN AMERICAN CULTURE.
Cat. II
An introduction to various aspects of life in Latin American countries from early times to the present. Focusing on the social and political development of Latin America, the course will reveal the unity and diversity that characterize contemporary Latin American culture. Typical topics for study include: the precolumbian civilizations and their cultural legacy; the conquistadores and the colonial period; the independence movements; the search for and the definition of an American identity; the twentieth-century dictatorships; and the move toward democracy.
Recommended background: SP 3521 (Advanced Spanish I) and SP 3522 (Advanced Spanish II) or equivalent.
This course will be offered in 2012-13 and in alternating years thereafter.
This course satisfies the Inquiry Practicum requirement.

SP 3524. SPANISH-AMERICAN LITERATURE IN THE TWENTIETH CENTURY.
Cat. II
This course, taught in the Spanish language, focuses on the major literary movements in Spanish America, from the “Modernista” movement at the turn of the century to the Latin American “Boom” of the 1960s to the political literature of the ’70s and ’80s. The work of representative authors, such as Rubén Darío, Julio Cortázar, Rosario Castellanos, Elena Poniatowska, will be discussed.
Recommended background: SP 3521 (Advanced Spanish I) and SP 3522 (Advanced Spanish II) or equivalent.
This course will be offered in 2011-12 and in alternating years thereafter.
This course satisfies the Inquiry Practicum requirement.

SP/ID 3525. SPANISH AMERICAN FILM/MEDIA: CULTURAL ISSUES.
Cat. II
Through Latin American and Caribbean films, and other media sources, this course studies images, topics, and cultural and historical issues related to modern Latin American and the Caribbean. Within the context and influence of the New Latin American Cinema and/or within the context of the World Wide Web, radio, newspapers, and television the course teaches students to recognize cinematographic or media strategies of persuasion, and to understand the images and symbols utilized in the development of a national/regional identity. Among the topics to be studied are: immigration, gender issues, national identity, political issues, and cultural hegemonies.
Taught in advanced level Spanish. May be used toward foreign language Minor, or Major.
Recommended Background: SP 2521 and SP 2522, and SP 3523.
This course will be offered in 2011-12 and in alternating years thereafter.
This course satisfies the Inquiry Practicum requirement.

SP/ID 3526. COMPARATIVE BUSINESS ENVIRONMENTS.
Cat. II
The basis of this course is a comparative study and analysis of specific Latin American and Caribbean business practices and environments, and the customs informing those practices. SP/ID 3526 focuses on countries such as Mexico, Argentina, Chile, Puerto Rico, and Costa Rica. The course’s main objective is to study communication strategies, business protocol, and negotiation practices in the countries mentioned above. Through oral presentations and written essays, students will have the opportunity to explore other countries in Latin America and the Caribbean.
Taught in advanced level Spanish. May be used toward foreign language Minor, or Major.
Recommended Background: SP 2521 and SP 2522.
This course will be offered in 2012-13 and in alternating years thereafter.
This course satisfies the Inquiry Practicum requirement.

SP/ID 3527. TECHNICAL AND BUSINESS SPANISH.
Cat. II
The course focuses on the linguistic concepts, terminology, and grammar involved in business and technical Spanish. Students will be required to produce and edit business documents such as letters, job applications, formal oral and written reports, etc. The objective of this course is to help students develop the basic written and oral communication skills to function in a business environment in Latin America and the Caribbean.
Recommended background: SP 2521 and SP 2522.
This course will be offered in 2011-12 and in alternating years thereafter.
This course satisfies the Inquiry Practicum requirement.

SP 3528. SPANISH CULTURE AND CIVILIZATION.
Cat. II
This course is an introduction to various aspects of life in Spain, from early times to the present. The main focus is on Spain’s social, political, and cultural development and its experience of diversity within its European context. Typical topics for study include: The Reconquista and the Arab influence in Spanish culture, the Spanish monarchy, its evolution into a democracy, the development of modern politics, the importance of the Spanish Civil war, and the influence of writers (such as Federico García Lorca), painters (such as Pablo Picasso), and art in general in modern Spanish culture. This course is taught in Spanish.
Recommended background: SP 3521 (Advanced Spanish I) and SP 3522 (Advanced Spanish II) or equivalent.
This course will be offered in 2011-12 and in alternating years thereafter.
This course satisfies the Inquiry Practicum requirement.
SP/ID 3529. CARIBBEANENESS: VOICES OF THE SPANISH CARIBBEAN.
Cat II
A survey of Caribbean literature and arts that takes a multimedia approach to examining the different voices that resonate from the Spanish Caribbean and what appears to be a constant search for identity. By studying the works of major authors, films, music and the plastic arts, we will examine the socio-cultural context and traditions of this region in constant search for self-definition. Special attention will be given to the influential role ethnicity, colonialism, gender and socio-economic development play in the interpretation of works from Puerto Rico, Cuba, the Dominican Republic, Colombia and Venezuela as well as those of the Caribbean diaspora. This course is taught in Spanish.
Recommended background: SP 3521 (Advanced Spanish I) and SP 3522 (Advanced Spanish II) or equivalent.
This course will be offered in 2011-12 and in alternating years thereafter. This course satisfies the Inquiry Practicum requirement.

SP/ID 3530. SPANISH FILM/MEDIA: CULTURAL ISSUES.
Cat II
Through Spanish films, and other media sources, this course studies images, topics, and cultural and historical issues that have had an impact in the creation of a modern Spanish nation. This course focuses on current political and ideological issues (after 1936), the importance of Spanish Civil war, gender identity, and class, cultural and power relationships. This course is taught in Spanish.
This course will be offered in 2012-13 and in alternating years thereafter. This course satisfies the Inquiry Practicum requirement.

SP/ID 3531. CONTEMPORARY US LATINO LITERATURE & CULTURE.
Cat II
This course introduces students to the field of Latino studies, paying particular attention to the cultural productions of U.S. Latinos in film, theater, music, fiction writing and cultural criticism. At the same time that this course reflects upon a transnational framework for understanding the continuum between U.S. Latinos and Latin American/Caribbean communities, we closely examine more U.S. based arguments supporting and contesting the use of Latino as an ethnic-racial term uniting all U.S. Latino communities. We examine the ways in which U.S. Latinos have manufactured identities within dominant as well as counter cultural registers. In this course, special attention is given to the aesthetics of autobiography and to how Latino writers experiment with this genre in order to address changing constructions of immigration, language, exile, and identity. This course is taught in English.
This course will be taught in 2012-13 and in alternating years thereafter. This course satisfies the Inquiry Practicum requirement.

SP3532. STUDIES IN SPANISH LITERATURE: ARTISTIC EXPRESSION AND NATION BUILDING.
Cat II
This course introduces students to the study of Spanish literature through analytical readings of essays, poetry, drama, and fiction of representative Spanish writers from medieval to contemporary times. The selected authors to be studied reflect Spanish society's cultural and political efforts conducive to a nation building process. Among the topics to be covered are: Literary and artistic movements, nationalist and religious discourses, cultural miscegenation, gender issues, regional, political and class conflicts, the role of the intellectual, and strategies for the construction of identities.
This course is taught in Spanish.
Recommended Background: SP 3522 and SP 3528.
This course will be offered in 2012-13 and in alternating years thereafter. This course satisfies the Inquiry Practicum requirement.

INTERACTIVE MEDIA AND GAME DEVELOPMENT

IMGD 1000. CRITICAL STUDIES OF INTERACTIVE MEDIA AND GAMES.
Cat. I
This course introduces non-technical studies of computer-based interactive media and games. The course develops a vocabulary for discussing games and other interactive media, and tools for analyzing them. Students are expected to provide written critiques using the critical approaches presented in the course. The games and other interactive media critiqued may be commercially available or under development.

IMGD 1001. THE GAME DEVELOPMENT PROCESS.
Cat. I
This course discusses the process of game development. It examines the roles of different participants in the development process and how the technical development and the artistic development proceed in tandem. Group work is emphasized, especially the importance of collaboration between technical and artistic efforts. Students are expected to participate in game development using appropriate game development tools.

IMGD 1002. STORYTELLING IN INTERACTIVE MEDIA AND GAMES.
Cat. I
This course explores different types of story within gaming and other interactive media. It delineates between linear, branching, and emergent storytelling, identifies hybrids, and finds new modes of making compelling narrative. A variety of games are discussed, including early text-based adventures, role-playing games, shooters, and strategy games. Students will construct characters, situations, and narratives through game play and scripted cut scenes. Students will explore and use visual storytelling techniques.

IMGD 2000. SOCIAL ISSUES IN INTERACTIVE MEDIA AND GAMES.
Cat. I
This course provides students with a realistic assessment of the potential and problems related to interactive media and games, especially computer games, and their effects on society. Topics include individual and group behavior, diversity, human responsibility, ethical and legal issues, and intellectual property. The course examines the issues from various points of view, and discovers the political, social, and economic agendas of the people or groups championing those points of view. Students will write papers, participate in discussions, and research related topics.
Recommended background: IMGD 1000.

IMGD 2001. PHILOSOPHY AND ETHICS OF COMPUTER GAMES.
Cat. II
This course introduces students to some of the political and ethical dimensions of the new entertainment modalities. Students will explore such issues as representation and power (e.g., gaming and disability, and race stereotyping in games), phenomenology of virtual reality, capitalism and the commodification of leisure, gender and sexual violence, and cyberspace and democracy. Students will also develop critical tools for evaluating the ethical and social content of their own and others’ games. In addition to writing several analytical papers on the critical theory of technology, students will be encouraged to work on game designs exploring philosophical or social themes.
Recommended background: IMGD 1000.
Offered in 2012-13 and in alternating years thereafter.

IMGD 2005. MACHINIMA (FILM MAKING IN VIRTUAL ENVIRONMENTS).
Cat. I
This course will address the cinematographic and narrative techniques involved with film making using video-game technology. Creation and development of characters, environments, and narrative structures will be explored. Using commercial game engines and audio/video editors, students will write, design, and produce complete animated movies. Industrial and artistic applications of this filmmaking technique are discussed as well as how Machinima is contextualized in the history of film animation and visualization.
Recommended background: IMGD 1002.
IMGD/AR 2101. 3D MODELING.
Cat. I
This course focuses on the art of 3D computer modeling for graphics, animation, game design, and image visualization. Techniques in polygon, NURB, and subdiv modeling will be explored, as well as deformations, texture mapping, lighting, cameras, rendering, and MEL scripting. Realistic and stylized modeling concepts will be developed, including optimization for rigging and game design. Historical context in relation to traditional sculpture will be discussed.
Recommended background: AR 1100 and AR 1101.

IMGD/AR 2201. THE ART OF ANIMATION.
Cat. I
This course examines the fundamentals of computer generated 2D and 3D modeling and animation as they apply to creating believable characters and environments. Students will learn skeletal animation and traditional polygonal animation, giving weight and personality to characters through movement, environmental lighting, and changing mood and emotion. Students will be expected to master the tools of 3D modeling and skinning, and scripting of behaviors.
Recommended background: AR 1101.

IMGD 2500. DESIGN OF TABLETOP STRATEGY GAMES.
Cat. II
The objective of the course is to teach students how to design board strategy games. The design principles are transferable to other types of games, such as computer games. Game quality issues such as rules unambiguity, depth, complexity, branching width, balance, and historical content are examined. Basic elements and types of game rules, such as map gridding, restricted play choices, resource limitations, and depths of game economics are discussed. Central to the course is the game design project: students design, playtest, and develop their own game. One two-hour laboratory a week covers play, and playtesting, and supports the game design project.
Recommended background: IMGD 1000
This course will be offered in 2012-13 and in alternating years thereafter.

IMGD 3000. TECHNICAL GAME DEVELOPMENT I.
Cat. I
This course teaches technical Computer Science aspects of game development, with the focus of the course on low-level programming of a computer game. Topics include 2D and 3D game engines, simulation-type games, analog and digital controllers and other forms of tertiary input. Students will implement games or parts of games, including exploration of graphics, sound, and music as it affects game implementation.
Recommended background: CS 2303.

IMGD 3500. ARTISTIC GAME DEVELOPMENT I.
Cat. I
This course focuses on the unique problems presented to the artist when working in game development. Students learn to work with 2D sprite-based art, including tiling and simple animation. They then explore 3D architecture, level design, texturing, and environmental animation. Students will use art to create compelling game experiences through environments by designing their own levels in both 2D and 3D games.
Recommended background: AR 3000.

IMGD 4000. TECHNICAL GAME DEVELOPMENT II.
Cat. I
This course focuses on the application of advanced Computer Science topics as they impact game development. Networking and distributed systems issues are addressed, including scalability and latency compensation techniques, for designing games for a online multi-player environments. AI, graphics and physics techniques specific to game development are discussed. Students will implement games or parts of games that apply advanced Computer Science topics.
Recommended background: IMGD 3000.

IMGD 4100. ARTIFICIAL INTELLIGENCE FOR INTERACTIVE MEDIA AND GAMES.
Cat II
Advanced software design and programming techniques from artificial intelligence are key contributors to the experience of modern computer games and virtual environments, either by directly controlling a non-player character or through more subtle manipulation of the environment. This course will cover the current state of the art in this area, as well as prepare students for the next generation of AI contributions. We will study the application of AI techniques such as search, planning, machine learning, emotion modeling and natural language processing, to game problems such as navigation, strategy, believability and narrative control. Students will implement several small AI demonstration games.
Recommended background: IMGD 4000.
Students may not receive credit for both IMGD 4100 and IMGD 400X.

IMGD 4200. HISTORY AND FUTURE OF IMMERSIVE AND INTERACTIVE MEDIA.
Cat II
This course will familiarize students with the history of the development, deployment, commercialization, and evolution of immersive and active media. The lesson plan will cover a broad range of enabling technologies, such as geometric perspective drawing, pre-20th-century panoramic displays, photography and the stereoscope, sound recording and reproduction, motion pictures, radio and television, the planetarium, immersive and 3-dimensional cinema, and special attraction venues, with a particular focus on digital games. Current trends and future directions will also be considered. Students will attend seminars and lectures, read and discuss texts on media history and aesthetics, and write an original research paper. Midterm and final exams test students’ knowledge and understanding of important events and developments. A student may not receive credit for both IMGD 4200 and IMGD 5200.
Recommended background: IMGD 1000, EN 2211 and either IMGD 2000 or IMGD 2001.
Students may not receive credit for both IMGD 4200 and IMGD 402X.

IMGD 4500. ARTISTIC GAME DEVELOPMENT II.
Cat. I
This course focuses on the integration and organization of the various artistic elements used in game development. The course examines user interaction, interface design, and existing paradigms in current games. Students will combine elements of level design, animation, music, sound, and writing to create an aesthetically appealing game.
Recommended background: IMGD 1002, IMGD 3500, MU 1611.

IMGD 4600. SERIOUS GAMES.
Cat. II
This course explores the application of the technologies and design principles of interactive media and game development beyond traditional entertainment. The purpose of such applications is typically to change people’s behaviors, knowledge and/or attitudes in diverse areas including health care, training, education, simulation, politics, marketing and art. Students read about, experiment with, compare and discuss examples, as well as the underlying philosophies and issues specific to this genre, such as domain analysis and rigorous evaluation. Students in groups also research a new application and produce a detailed design document and mock-up. Advanced programming skill is not required, but a background in game design is strongly recommended.
Recommended background: IMGD 1001 and either IMGD 2000 or IMGD 2001.
Students may not receive credit for both IMGD 4600 and IMGD 404X.

IMGD 4700. ADVANCED STORYTELLING: QUEST LOGIC AND LEVEL DESIGN.
Cat. I
This course provides an in-depth examination of storytelling as it is currently done in 2D and 3D games through a study of quests and construction of gaming spaces. Level designers turn stories into games through building virtual spaces and populating them with non-player characters who have their own objectives. Cinematics are used to extend the narrative space. The course requires students to build multiple virtual spaces that have a history and a population with present needs. Students need to work out plotting through the logic of a quest, build several areas that supports that logic and create cinematics to extend their narrative space.
Recommended background: IMGD 1002, or equivalent knowledge.
Students may not receive credit for both IMGD 4700 and IMGD 403X.
INTERDISCIPLINARY COURSES

FY 1100 & FY 1101. THE GREAT PROBLEMS SEMINARS.
Cat. I
The Great Problems Seminars (GPS) are courses designed to engage Worcester Polytechnic Institute's first-year students with current events, societal problems, and human needs. Each seminar starts with an important problem and introduces some of the key disciplinary tools that could be used to attack the problem. The focus for most of the second half of the course will be a research project related to the GPS theme. Students will present their project work in a poster session at the end of the term. Each seminar is developed and presented by an interdisciplinary team of faculty. To participate, students must enroll in the two course sequence. Academic credit for the GPS will depend on the theme and the faculty who develop the seminar.

ID/SS 2050. SOCIAL SCIENCE RESEARCH FOR THE IGP.
Cat. I
This course is open to students accepted to off-campus IGP centers and programs. The course introduces students to the processes of research design, methods for social science research, and analysis. It also provides practice in specific research and field skills using the project topics students have selected in conjunction with sponsoring agencies. Students learn to develop social science hypotheses based upon literature reviews in their topic areas and apply concepts drawn from social psychology, anthropology, sociology, economics and other areas as appropriate. Students make presentations, write an organized project proposal, and develop a communication model for reporting their project findings.

ID 3100. TEACHING METHODS IN MATHEMATICS AND SCIENCE.
Cat. II
Within the context of contemporary secondary education in mathematics and science (biology, chemistry, physics), ID 3100 introduces and demonstrates effective teaching methods as they relate to curriculum goals and current methods of assessment. These methods take into account diverse learning styles as well as various technological resources. Topics to be covered include: a brief history of education; curriculum and course guidelines (Massachusetts Education Reform and regulations 603 CMR 7.00, state curricular frameworks, national standards); legal issues; developing a course syllabus; the issue of breadth versus depth in course planning and delivery. The course also covers practical questions of organizing, delivering and assessing a course. This course is intended primarily for students interested in completing the Massachusetts requirements for teacher licensing. (See www.wpi.edu/~goulet/teacher_prep).
This program is aimed primarily at majors in mathematics, physics, chemistry and biology wishing to be licensed to teach in middle or high school in one of those disciplines. A portion of the course requires the observation of master teachers at the Massachusetts Academy of Mathematics and Science, who will work with all students in the course to assist them in beginning to acquire the appropriate skills to conduct their own classes in mathematics or science at the secondary school level.
Recommended background: SS 2401. Psychology of Education.
This course will be offered in 2012-13 and in alternating years thereafter.

ID/AR 3150. LIGHT, VISION AND UNDERSTANDING.
Cat. II
By using material from the sciences and the humanities this course examines the ways in which ideas of knowledge and of human nature have been fashioned. The specific topics include physical theories about light, biological and psychological theories of visual perception, and artistic theories and practices concerned with representation. The mixing of material from different academic disciplines is deliberate, and meant to counter the notion that human pursuits are "naturally" arranged in the neat packages found in the modern university. The course draws upon the physical and social sciences, and the humanities, to examine how those fields relate to one another, and how they produce knowledge and self-knowledge. Cultural as well as disciplinary factors are assessed in this process.
Light, Vision and Understanding is conducted as a seminar. The diverse collection of reading materials includes a number of primary texts in different fields. In addition, the students keep a journal in which they record the results of numerous individual observations and experiments concerning light and visual perception. The course can fit into several Sufficiency areas as well as serve as a starting point for an IGP. There are no specific requirements for this course, although some knowledge of college-level physics, as well an acquaintance with the visual arts, is helpful.
This course will be offered in 2012-13 and in alternating years thereafter.

ID/GN 3515. TECHNICAL TOPICS IN GERMAN.
Cat. II
Technical topics are addressed and discussed entirely in German. German-speaking faculty from several WPI science and engineering departments, as well as lecturers from outside the university, present a range of topics at an introductory level. The focus of the course is on the use and development of German language skills in a technical context, which will include lectures, presentations, discussions, problem solving, and writing on technical topics. The course can be counted towards the Humanities and Arts Requirement or a minor in German. As the course is to be conducted entirely in German, knowledge of German sufficient for advanced conversations and detailed writing (such as students acquire in GN 3512, Advanced German II, or equivalent) is strongly recommended.
This course will be offered in 2012-13 and in alternating years thereafter.

ID/SP 3525. SPANISH AMERICAN FILM/MEDIA: CULTURAL ISSUES.
Cat. II
Through Latin American and Caribbean films, and other media sources, this course studies images, topics, and cultural and historical issues related to modern Latin American and the Caribbean. Within the context and influence of the New Latin American Cinema and/or within the context of the World Wide Web, radio, newspapers, and television the course teaches students to recognize cinematic and media strategies of persuasion, and to understand the images and symbols utilized in the development of a national/regional identity. Among the topics to be studied are: immigration, gender issues, national identity, political issues, and cultural hegemonies.
Taught in advanced level Spanish. May be used toward foreign language Minor, or Major.
Recommended Background: SP 2521 and SP 2522, and SP 3523.
This course will be offered in 2012-12 and in alternating years thereafter.

ID/SP 3526. COMPARATIVE BUSINESS ENVIRONMENTS.
Cat. II
The basis of this course is a comparative study and analysis of specific Latin American and Caribbean business practices and environments, and the customs informing those practices. ID/SP 3526 focuses on countries such as Mexico, Argentina, Chile, Puerto Rico, and Costa Rica. The course's main objective is to study communication strategies, business protocol, and negotiation practices in the countries mentioned above. Through oral presentations and written essays, students will have the opportunity to explore other countries in Latin America and the Caribbean.
Taught in advanced level Spanish. May be used toward foreign language Minor, or Major.
Recommended Background: SP 2521 and SP 2522.
This course will be offered in 2012-13 and in alternating years thereafter.

ID/SP 3527. TECHNICAL AND BUSINESS SPANISH.
Cat. II
The course focuses on the linguistic concepts, terminology, and grammar involved in business and technical Spanish. Students will be required to produce and edit business documents such as letters, job applications, formal oral and written reports, etc. The objective of this course is to help students develop the basic written and oral communication skills to function in a business environment in Latin America and the Caribbean.
Recommended Background: SP 2521 and SP 2522.
This course will be offered in 2012-13 and in alternating years thereafter.

ID/SP 3529. CARIBBEANNESS: VOICES OF THE SPANISH CARIBBEAN.
Cat. II
A survey of Caribbean literature and arts that takes a multimedia approach to examining the different voices that resonate from the Spanish Caribbean and what appears to be a constant search for identity. By studying the works of major authors, films, music and the plastic arts, we will examine the socio-cultural context and traditions of this region in constant search for self-definition. Special attention will be given to the influential role ethnicity, colonialism, gender and socio-economic development play in the interpretation of works from Puerto Rico, Cuba, the Dominican Republic, Colombia and Venezuela as well as those of the Caribbean diaspora. This course is taught in Spanish.
Recommended Background: SP3521 (Advanced Spanish I) and SP 3522 (Advanced Spanish II) or equivalent.
This course will be offered in 2011-12 and in alternating years thereafter.
MA 1021. CALCULUS I.

Cat. I

This course provides an introduction to differentiation and its applications. Topics covered include: functions and their graphs, limits, continuity, differentiation, linear approximation, chain rule, min/max problems, and applications of derivatives.

Recommended background: Algebra, trigonometry and analytic geometry.

Students may not receive credit for both MA 1020 and MA 1021.

MA 1022. CALCULUS II.

Cat. I

This course provides an introduction to integration and its applications. Topics covered include: inverse trigonometric functions, Riemann sums, fundamental theorem of calculus, basic techniques of integration, volumes of revolution, arc length, exponential and logarithmic functions, and applications.

Recommended background: MA 1021. Although the course will make use of computers, no programming experience is assumed.

MA 1023. CALCULUS III.

Cat. I

This course provides an introduction to series, parametric curves and vector algebra. Topics covered include: numerical methods, indeterminate forms, improper integrals, sequences, Taylor’s theorem with remainder, convergence of series and power series, polar coordinates, parametric curves and vector algebra.

Recommended background: MA 1022. Although the course will make use of computers, no programming experience is assumed.

MA 1024. CALCULUS IV.

Cat. I

This course provides an introduction to multivariable calculus. Topics covered include: vector functions, partial derivatives and gradient, multivariable optimization, double and triple integrals, polar coordinates, other coordinate systems and applications.

Recommended background: MA 1023. Although the course will make use of computers, no programming experience is assumed.

MA 1031. INTRODUCTION TO ANALYSIS I.

Cat. I

This course provides the fundamentals of mathematical thinking and writing for mathematical proof in analysis. Topics covered include mathematical logic, set theory, functions, cardinality, topology of the real line, limits of sequences.

Recommended background: MA 1031

MA 1033. INTRODUCTION TO ANALYSIS III.

Cat. I

This course develops the theory of integration and provides an introduction to series of numbers and series of functions. Topics covered include the Fundamental Theorem of Calculus, integration by parts, change of variable, series, convergence tests, rearrangements of series, sequences and series of functions, power series, Taylor series.

Recommended background: MA 1032

MA 1034. INTRODUCTION TO ANALYSIS IV.

Cat. I

The course provides a rigorous introduction to multivariable analysis. Topics covered include vector algebra, functions of several variables, partial derivatives, gradient, multiple integrals, Green’s theorem, Stokes’ theorem, divergence theorem. Recommended background: MA 1033

MA 1101. CALCULUS I FOR BIOLOGY, BUSINESS, AND THE SOCIAL SCIENCES.

Cat. I

This course covers many of the topics of basic calculus, including functions, limits, derivatives and an introduction to integrals. The emphasis, however, is on concepts and applications relevant to business, social sciences and life sciences. A particular aim of the two-term sequence, MA 1101-MA 1102, is to build a foundation for courses in statistics. Appropriate technology will be introduced.

This is a terminal calculus sequence and is not recommended for students whose majors require one or more of MA 1023, MA 1024, and MA 2051. Academic credit can not be obtained for both MA 1101 and either of MA 1021 or MA 1020.

MA 1102. CALCULUS II FOR BIOLOGY, BUSINESS, AND THE SOCIAL SCIENCES.

Cat. I

This course is a continuation of MA 1101 and introduces topics such as numerical integration, functions of several variables, partial derivatives, double integrals, and introductory differential equations. Applications include the normal distribution, least squares linear regression, and growth and decay problems. The course involves the use of appropriate technology.

Recommended background: MA 1101.

As mentioned in the course description of MA 1101, this course is not recommended for students whose majors require one or more of MA 1023, MA 1024, and MA 2051. Academic credit can not be obtained for both MA 1102 and either of MA 1022 or MA 1120.

MA 1120. CALCULUS II. (SEMESTER VERSION)

Cat.I

The topics for integral calculus (MA 1022) are covered in this course: the concept of the definite integral, the Fundamental Theorem of Calculus, integration techniques, and applications of integration. Applications include: area, volume, arc length, center of mass, work, force, and exponential growth and decay. Logarithmic and exponential functions are studied in depth. Arithmetic and geometric sequences and series will also be covered. Key
historical events in the development of integral calculus are examined. Technology will be used as appropriate to support the material being studied. This course extends for 14 weeks and offers 1/3 unit of credit. It is designed for students who would benefit from additional contact hours and who need to strengthen their mathematical background. Although the course will make use of computers, no programming experience is assumed. Students may not receive credit for both MA 1120 and MA 1022 or MA 1102.

MA 2051. ORDINARY DIFFERENTIAL EQUATIONS. Cat. I
This course develops techniques for solving ordinary differential equations. Topics covered include: introduction to modeling using first-order differential equations, solution methods for linear higher-order equations, qualitative behavior of nonlinear first-order equations, oscillatory phenomena including spring-mass system and RLC-circuits and Laplace transform. Additional topics may be chosen from power series method, methods for solving systems of equations and numerical methods for solving ordinary differential equations. Recommended background: MA 1024.

MA 2071. MATRICES AND LINEAR ALGEBRA I. Cat. I
This course provides a study of computational techniques of matrix algebra and an introduction to vector spaces.
Topics covered include: matrix algebra, systems of linear equations, eigenvalues and eigenvectors, least squares, vector spaces, inner products, and introduction to numerical techniques, and applications of linear algebra.
Recommended background: None.

MA 2073. MATRICES AND LINEAR ALGEBRA II. Cat. I
This course provides a deeper understanding of topics introduced in MA 2071 and also continues the development of those topics. Topics covered include: abstract vector spaces, linear transformations, matrix representations of a linear transformation, characteristics and minimal polynomials, diagonalization, eigenvalues and eigenvectors, inner product spaces.
This course is design primarily for Mathematical Science majors and those interested in the deeper mathematical issues underlying linear algebra.
Undergraduate credit may not be earned both for this course and for MA 3071.
Recommended background: MA 2071.

MA 2201/CS 2022. DISCRETE MATHEMATICS. Cat. I
This course serves as an introduction to some of the more important concepts, techniques, and structures of discrete mathematics providing a bridge between computer science and mathematics.
Topics include functions and relations, sets, countability, groups, graphs, propositional and predicate calculus, and permutations and combinations.
Students will be expected to develop simple proofs for problems drawn primarily from computer science and applied mathematics.
Recommended background: None.

MA 2210. MATHEMATICAL METHODS IN DECISION MAKING. Cat. I
This course introduces students to the principles of decision theory as applied to the planning, design and management of complex projects. It will be useful to students in all areas of engineering, actuarial mathematics as well as those in such interdisciplinary areas as environmental studies. It emphasizes quantitative, analytic approaches to decision making using the tools of applied mathematics, operations research, probability and computations. Topics covered include: the systems approach, mathematical modeling, optimization and decision analysis. Case studies from various areas of engineering or actuarial mathematics are used to illustrate applications of the materials covered in this course.
Recommended background: MA 1024. Suggested background: Familiarity with vectors and matrices. Although the course makes use of computers, no programming experience is assumed. Students who have received credit for CE 2010 may not receive credit for MA 2210.

MA 2251. VECTOR AND TENSOR CALCULUS. Cat. I
This course provides an introduction to tensor and vector calculus, an essential tool for applied mathematicians, scientists, and engineers.
Topics covered include: scalar and vector functions and fields, tensors, basic differential operations for vectors and tensors, line and surface integrals, change of variable theorem in integration, integral theorems of vector and tensor calculus. The theory will be illustrated by applications to areas such as electostatics, theory of heat, electromagnetics, elasticity and fluid mechanics.
Recommended background: MA 1024.

MA 2271. GRAPH THEORY. Cat. II
This course introduces the concepts and techniques of graph theory—a part of mathematics finding increasing application to diverse areas such as management, computer science and electrical engineering. Topics covered include: graphs and digraphs, paths and circuits, graph and digraph algorithms, trees, cliques, planarity, duality and colorability.
This course is designed primarily for Mathematical Science majors and those interested in the deeper mathematical issues underlying graph theory.
Undergraduate credit may not be earned both for this course and for MA 3271.
Recommended background: MA 2071.
This course will be offered in 2012-13 and in alternating years thereafter.

MA 2273. COMBINATORICS. Cat. II
This course introduces the concepts and techniques of combinatorics—a part of mathematics with applications in computer science and in the social, biological, and physical sciences. Emphasis will be given to problem solving. Topics will be selected from: basic counting methods, inclusion-exclusion principle, generating functions, recurrence relations, systems of distinct representatives, combinatorial designs, combinatorial algorithms and applications of combinatorics.
This course is designed primarily for Mathematical Sciences majors and those interested in the deeper mathematical issues underlying combinatorics.
Undergraduate credit may not be earned both for this course and for MA 3273.
Recommended background: MA 2071.
This course will be offered in 2011-12 and in alternating years thereafter.

MA 2431. MATHEMATICAL MODELING WITH ORDINARY DIFFERENTIAL EQUATIONS. Cat. I
This course focuses on the theoretical foundations of ordinary equations while building models for physical and biological systems. Mathematical topics may include methods for solving systems of ordinary differential equations, existence and uniqueness theory, stability theory, phase-plane analysis and limit cycles. Examples will be chosen from electrical and mechanical oscillations, control theory, ecological models and reaction kinetics. Students will learn how to turn a real-life physical or biological problem into a mathematical one and to interpret the mathematical results.
This course is designed primarily for Mathematical Sciences majors and those interested in the deeper mathematical issues underlying mathematical modeling.
Undergraduate credit may not be earned both for this course and for MA 3431.
Recommended background: MA 1024, MA 2051 and MA 2071.

MA 2610. APPLIED STATISTICS FOR THE LIFE SCIENCES. Cat. I
This course is designed to introduce the student to statistical methods and concepts commonly used in the life sciences. Emphasis will be on the practical aspects of statistical design and analysis with examples drawn exclusively from the life sciences, and students will collect and analyze data. Topics covered include analytic and graphical and numerical summary measures, probability models for sampling distributions, the central limit theorem, and one and two sample point and interval estimation, parametric and non-parametric hypothesis testing, principles of experimental design, comparisons of paired samples and categorical data analysis. Undergraduate credit may not be earned both for this course and for MA 2611.
Recommended background: MA 1022.

MA 2611. APPLIED STATISTICS I. Cat. I
This course is designed to introduce the student to data analytic and applied statistical methods commonly used in industrial and scientific applications as well as in course and project work at WPI. Emphasis will be on the practical aspects of statistics with students analyzing real data sets on an interactive computer package.
Topics covered include analytic and graphical representation of data, exploratory data analysis, basic issues in the design and conduct of experimental and observational studies, the central limit theorem, one and two sample point and interval estimation and tests of hypotheses.
Recommended background: MA 1022.
MA 2612. APPLIED STATISTICS II.
Cat. I
This course is a continuation of MA 2611.
Topics covered include simple and multiple regression, one and two-way tables for categorical data, design and analysis of one factor experiments and distribution-free methods.
Recommended background: MA 2611.

MA 2621. PROBABILITY FOR APPLICATIONS.
Cat. I
This course is designed to introduce the student to probability.
Topics to be covered are: basic probability theory including Bayes theorem; discrete and continuous random variables; special distributions including the Bernoulli, Binomial, Geometric, Poisson, Uniform, Normal, Exponential, Chi-square, Gamma, Weibull, and Beta distributions; multivariate distributions; conditional and marginal distributions; independence; expectation; transformations of univariate random variables.
Recommended background: MA 1024.

MA 2631. LINEAR PROGRAMMING.
Cat. I
This course is designed to introduce the student to probability.
Topics covered include: the primal and dual simplex algorithms, duality theory, parametric analysis, network flow models and, as time permits, bounded variable linear programs; optimal matching, integrality of polyhedra, matroids, and NP-completeness.
Recommended background: At least one of MA 2271, MA 2273 or MA 3231.
This course will be offered in 2012-13 and in alternating years thereafter.

MA 2637/CS 4032. NUMERICAL METHODS FOR LINEAR AND NONLINEAR SYSTEMS.
Cat. I
This course provides an introduction to modern computational methods for linear and nonlinear equations and systems and their applications.
Topics covered include: solution of nonlinear scalar equations, direct and iterative algorithms for the solution of systems of linear equations, solution of nonlinear systems, the eigenvalue problem for matrices. Error analysis will be emphasized throughout.
Recommended background: MA 2071. An ability to write computer programs in a scientific language is assumed.

MA 2651. ADVANCED ORDINARY DIFFERENTIAL EQUATIONS.
Cat. II
The first part of the course will cover existence and uniqueness of solutions, continuous dependence of solutions on parameters and initial conditions, maximal interval of existence of solutions, Gronwall's inequality, linear systems and the variation of constants formula, Floquet theory, stability of linear and perturbed linear systems. The second part of the course will cover material selected by the instructor. Possible topics include: Introduction to dynamical systems, stability by Lyapunov's direct method, study of periodic solutions, singular perturbation theory and nonlinear oscillation theory.
Recommended background: MA 2431 and MA 3832.
This course will be offered in 2011-12 and in alternating years thereafter.

MA 2675. CALCULUS OF VARIATIONS.
Cat. I
This course covers the calculus of variations and select topics from optimal control theory. The purpose of the course is to expose students to mathematical concepts and techniques needed to handle various problems of design encountered in many fields, e. g. electrical engineering, structural mechanics and manufacturing.
Topics covered will include: derivation of the necessary conditions of a minimum for simple variational problems and problems with constraints, variational principles of mechanics and physics, direct methods of minimization of functions, Pontryagin's maximum principle in the theory of optimal control and elements of dynamic programming.
Recommended background: MA 2051.
This course will be offered in 2012-13 and in alternating years thereafter.

MA 3231. LINEAR PROGRAMMING.
Cat. I
This course considers the formulation of real-world optimization problems as linear programs, the most important algorithms for their solution, and techniques for their analysis.
Topics covered include: the primal and dual simplex algorithms, duality theory, parametric analysis, network flow models and, as time permits, bounded variable linear programs or interior methods.
Recommended background: MA 2071.

MA 3233. DISCRETE OPTIMIZATION.
Cat. II
Discrete optimization is a lively field of applied mathematics in which techniques from combinatorics, linear programming, and the theory of algorithms are used to solve optimization problems over discrete structures, such as networks or graphs.

The course will emphasize algorithmic solutions to general problems, their complexity, and their application to real-world problems drawn from such areas as VLSI design, telecommunications, airline crew scheduling, and product distribution.
Topics will be selected from: Network flow, optimal matching, integrality of polyhedra, matroids, and NP-completeness.
Undergraduate credit may not be earned both for this course and for MA 4233.
Recommended background: At least one of MA 2271, MA 2273 or MA 3231.
This course will be offered in 2012-13 and in alternating years thereafter.

MA 3457/CS 4033. NUMERICAL METHODS FOR CALCULUS AND DIFFERENTIAL EQUATIONS.
Cat. I
This course provides an introduction to modern computational methods for differential and integral calculus and differential equations.
Topics covered include: interpolation and polynomial approximation, approximation theory, numerical differentiation and integration, numerical solutions of ordinary differential equations. Error analysis will be emphasized throughout.
Recommended background: MA 2051. An ability to write computer programs in a scientific language is assumed. Undergraduate credit may not be earned for both this course and for MA 3255/CS 4031.

MA 3471. ADVANCED ORDINARY DIFFERENTIAL EQUATIONS.
Cat. II
This course will be offered in 2012-13 and in alternating years thereafter.

MA 3475. CALCULUS OF VARIATIONS.
Cat. I
This course covers the calculus of variations and select topics from optimal control theory. The purpose of the course is to expose students to mathematical concepts and techniques needed to handle various problems of design encountered in many fields, e. g. electrical engineering, structural mechanics and manufacturing.
Topics covered will include: derivation of the necessary conditions of a minimum for simple variational problems and problems with constraints, variational principles of mechanics and physics, direct methods of minimization of functions, Pontryagin's maximum principle in the theory of optimal control and elements of dynamic programming.
Recommended background: MA 2051.
This course will be offered in 2012-13 and in alternating years thereafter.

MA 3627. APPLIED STATISTICS III.
Cat. II
This course continues the exploration of statistics for scientific and industrial applications, begun in MA 2611 and MA 2612. Topics covered include the design and analysis of general factorial experiments, two-level factorial and fractional factorial experiments, Taguchi methods, response surface analysis, and statistical quality control.
Recommended background: MA 2612.
This course will be offered in 2011-12, and in alternating years thereafter.
MA 3831. ADVANCED CALCULUS I.
Cat. I
Advanced Calculus is a two-part course giving a rigorous presentation of the important concepts of classical real analysis.
Topics covered include: basic set theory, elementary topology of Euclidean spaces, limits and continuity, differentiation Reimann-Stieltjes integration, infinite series, sequences of functions, and topics in multivariate calculus.
Recommended background: MA 2051 and MA 2071.

MA 3832. ADVANCED CALCULUS II.
Cat. I
MA 3832 is a continuation of MA 3831.
For the contents of this course, see the description given for MA 3831.
Recommended background: MA 3831.

MA 4213. RISK THEORY.
Cat. II
This course covers topics in risk theory as it is applied, under specified assumptions, to insurance.
Topics covered include: economics of insurance, short term individual risk models, single period and extended period collective risk models, and applications.
Recommended background: MA 2631.
This course will be offered in 2011-12 and in alternating years thereafter.

MA 4214. SURVIVAL MODELS.
Cat. II
Survival models are statistical models of times to occurrence of some event. They are widely used in areas such as the life sciences and actuarial science (where they model such events as time to death, or to the development or recurrence of a disease), and engineering (where they model the reliability or useful life of products or processes). This course introduces the nature and properties of survival models, and considers techniques for estimation and testing of such models using realistic data.
Topics covered will be chosen from: parametric and nonparametric survival models, censoring and truncation, nonparametric estimation (including confidence intervals and hypothesis testing) using right-, left-, and otherwise censored or truncated data.
Recommended background: MA 3631.
This course will be offered in 2012-13, and in alternating years thereafter.

MA 4235. MATHEMATICAL OPTIMIZATION.
Cat. II
This course explores theoretical conditions for the existence of solutions and effective computational procedures to find these solutions for optimization problems involving nonlinear functions.
MECHANICAL ENGINEERING

The second digit in mechanical engineering course numbers is coded as follows:

- 0 — General mechanical engineering
- 1 — Materials
- 2 — Design
- 3 — Thermal—fluids
- 4 — Engineering mechanics
- 5 — Fluid mechanics—hydraulics
- 6 — Aerospace
- 7 — Materials
- 8 — Manufacturing
- 9 — Engineering experimentation

ME 1520. THE TECHNOLOGY OF ALPINE SKIING.
Cat. I
This course explores science and engineering issues associated with equipment and technique for alpine skiing, particularly racing. A diverse group of technical subjects related to engineering mechanics are discussed: tribology, beams, rigid body motion, material science, machining and biomechanics. Specifically we will examine: ski-snow interactions, technique for gliding, turning and stepping, selection of line in racing, equipment design, testing and performance; and ski injuries. We will also address issues in the epidemiology of skiing injuries, the calculation of the cost of ski injuries to society, the impact of ski equipment technology on litigation and the impact of litigation on equipment and trail design.
This course will be offered in 2012-13 and in alternating years thereafter.

ME 1800. MANUFACTURING SCIENCE, PROTOTYPING, AND COMPUTER-CONTROLLED MACHINING.
Cat I
This course introduces students to manufacturing science and engineering and prototype part production. It emphasizes CNC (computer-controlled) machining. Students will learn how to go from a solid (CAD, computer-aided design) model to a machined part, using CAM software (computer-aided manufacturing) and CNC machining. They will also be exposed to associated issues in manufacturing process analysis, engineering design, material science, and in dimensional and surface metrology. Using machining as an example, the science of manufacturing processes is developed in a combination of class work and laboratory experience. The laboratory experience includes an experimental component that relates process variables in machining with performance and machined part quality. Students whose project work will necessitate fabrication of parts and those who want a background in manufacturing process science and engineering should take this course.

ME 2300. INTRODUCTION TO ENGINEERING DESIGN.
Cat. I
Real world engineering design problems usually have more than one correct solution. This course utilizes a realistic design process to introduce students to the methods and techniques for solving engineering problems. Lectures will support the design projects and may cover engineering economics, fluid dynamics, heat transfer, mechanics, statistics, and basic circuits. No prior knowledge of fluids, heat transfer, economics, statistics or electrical circuits is required. Laboratory sessions will be used to build, test and demonstrate various designs.
This course is designed for sophomores and juniors to provide a broad overview of engineering design.
The course includes a significant writing component and makes extensive use of PCs for word processing, spreadsheet calculations and programming.
Recommended background: Ordinary Differential Equations (MA 2051), mechanics (PH 1110), statics (ES 2501), any programming language.

ME 2713. ASTRONAUTICS.
Cat. I
Topics studied: Orbital mechanics including spacecraft maneuvering and station keeping, transfer orbits, and interplanetary transfers; space environment including characteristics of low earth highly elliptical and geosynchronous orbits; ascent and reentry trajectories.
Recommended background: Dynamics (ES 2503).

ME 2820. MATERIALS PROCESSING.
Cat. I
An introduction to material processing in manufacturing. This course provides important background for anyone interested in manufacturing, design engineering design, sales, or management.
Processing of polymers, ceramics, metals and composites is discussed. Processes covered include: rolling, injection molding, forging, powder metallurgy, joining and machining. The relationships between materials, processes, processing parameters and the properties of manufactured parts are developed. During the course the students should develop the ability to choose materials, processes, and processing parameters for designing manufacturing procedures to take a prototype part to production.

ME 3310. KINEMATICS OF MECHANISMS.
Cat. I
An introduction to the synthesis and analysis of linkages, cams and gears trains is presented. The design process is introduced and used to solve unstructured design problems in linkage and cam design. Algebraic and graphical techniques to analyze the displacement, velocity and acceleration of linkages and cams are developed. Computer programs for the design and analysis of linkages are used by students. Results of student design projects are presented in professional engineering reports.
Recommended background: Ordinary Differential Equations (MA 2051), statics (ES 2501), dynamics (ES 2503).

ME 3311. DYNAMICS OF MECHANISMS AND MACHINES.
Cat. I
This course provides an in-depth study of forces in dynamic systems. Dynamic force analysis is developed using matrix methods. Computer programs are used to solve the sets of simultaneous equations derived by students for realistic, unstructured design problems. Inertial and shaking forces, elementary mechanical vibrations, torque-time functions, rotational and reciprocating balance and cam dynamics are covered using the internal combustion engine as a design example. Students execute unstructured design projects and prepare professional engineering reports on the results. Computers are used extensively to solve the dynamic equations.
Recommended background: Ordinary Differential Equations (MA 2051), statics (ES 2501), dynamics (ES 2503), kinematics (ME 3310), linear algebra.
This course will be offered in 2012-13 and in alternating years thereafter.

ME 3320. DESIGN OF MACHINE ELEMENTS.
Cat. I
This is an introductory course in mechanical design analysis, and it examines stress and fatigue in many machine elements. Common machine elements are studied and methods of selection and design are related to the associated hardware.
Topics covered include: combined stresses, fatigue analysis, design of shafts, springs, gears, bearings and miscellaneous machine elements.
Recommended background: mechanics (ES 2501, ES 2502, ES 2503), materials (ME 1800, ME 2820), computer programming (CS 1101 or CS 1102).

ME 3410. COMPRESSIBLE FLUID DYNAMICS.
Cat. I
In this course, students are introduced to various compressibility phenomena such as compression (shock) and expansion waves. Conservation laws and thermodynamic principles are applied to the description of flows in which compressibility effects are significant. One-dimensional models are applied to analysis of flow in variable area ducts, normal and oblique shock waves, expansion waves, and flows with friction and heat addition. Numerous applications from engineering are investigated including supersonic inlets, rocket nozzles, supersonic wind tunnels, gas delivery systems, and afterburning jet engines.
Recommended background: thermodynamics (ES 3001, CH 3510 or equivalent), fluid dynamics (ES 3004 or equivalent).
ME 3501. ELEMENTARY CONTINUUM MECHANICS.
Cat. II
In typical mathematics courses, students learn principles and techniques by solving many short and specially prepared problems. They rarely gain experience in formulating and solving mathematical equations that apply to real life engineering problems. This course will give students this type of applied mathematical experience.
The course emphasizes the application of basic laws of nature as they apply to differential elements which lead to differential equations that need to be solved; all of these ideas are used in higher level engineering science courses such as fluid mechanics, heat transfer, elasticity, etc. Emphasis will be placed on understanding the physical concepts in a problem, selecting appropriate differential elements, developing differential equations, and finding ways to solve these equations. Limitations on the mathematical solutions due to assumptions made will be considered.
Recommended background: Ordinary Differential Equations (MA 2501), statics (ES 2501), dynamics (ES 2503).
This course will be offered in 2012-13 and in alternating years thereafter.

ME 3506. REHABILITATION ENGINEERING.
Cat. I
The course exposes the students to the use of technology to design devices to ameliorate the handicaps of individuals with disabilities. This course focuses on the design process for assistive devices including defining the problem, setting design criteria, developing preliminary designs, selecting, analyzing and testing a final design. Human factors are integrated into all phases of the design process.
Topics include: ergonomics, physical and cognitive parameters that effect the user interface, safety, economics, reliability and esthetics. Design and analysis of devices used for mobility and in daily activities in residential, educational and vocational settings. Laboratory sessions will be used to develop conceptual designs that solve real problems.
Recommended background: mechanics (ES 2501, ES 2502, ES 2503), kinematics (ME 3310), design (ME 2300), materials (ME 1800, ME 2820), electrical engineering (ECE 3601).

ME 3602. INCOMPRESSIBLE FLUIDS.
Cat. I
This course covers inviscid and viscous incompressible fluid dynamics at an intermediate level. Topics include: fluid kinematics and deformation; integral conservation laws of mass, momentum and energy for finite systems and control volumes; differential conservation laws of mass, momentum and energy; the Navier-Stokes equations and solution methods; the incompressible Euler equations and Bernoulli’s equation; the streamfunction and the velocity potential; incompressible, inviscid, irrotational flow theory and solution methodology; elementary potential flows, the superposition principle and its applications to flows over solid bodies; two-dimensional incompressible, viscous boundary layer, Prandtl’s theory, the Blasius solution and its application; other analytical solutions for two-dimensional viscous and inviscid incompressible channel flows.
Recommended background: thermodynamics (ES 3001, CH 3510 or equivalent), fluid dynamics (ES 3004 or equivalent).

ME 3703. INTRODUCTION TO CONTROL OF DYNAMICAL SYSTEMS.
Cat. I
The course introduces the mathematical modeling and control of dynamical systems found in aerospace and mechanical engineering applications.
Topics include: introduction to feedback control analysis and synthesis of linear dynamic systems; transient response analysis of first and second order systems (thermal, pneumatic, hydraulic, and mechanical); introduction to state-space modeling and representation of control systems; linearization of nonlinear systems; stability analysis using Routh’s criterion and Lyapunov methods; system analysis using frequency response methods; introduction to the design of controllers in time and frequency domain. The analysis and design will be accomplished with Matlab/Simulink® software.
Recommended background: ordinary differential equations (MA 2051 or equivalent), dynamics (ES2503, PH 2201, PH2202 or equivalent), fluid dynamics (ES3004, ME3602 or equivalent), electricity and magnetism (PH 1120 or PH 1121 or equivalent).

ME 3711. AERODYNAMICS.
Cat. I
This course introduces students to the aerodynamics of airfoils, wings, and aircraft in the subsonic and supersonic regimes. Topics covered include: prediction of aerodynamic forces (lift, drag) and moments, dynamic similarity, experimental techniques in aerodynamics, Kutta-Joukowski theorem, circulation, thin airfoil theory, panel methods, finite wing theory, subsonic compressible flow over airfoils, linearized supersonic flow, and viscous flow over airfoils.
Recommended background: incompressible fluid dynamics (ME 3602 or equivalent).

ME 3712. AEROSPACE STRUCTURES.
Cat. I
This is a course in solid mechanics that covers stress analysis of aerospace structures. It begins with an overview of stress, strain, three-dimensional elasticity theory, and stress-strain relations for anisotropic materials. Advanced topics include general torsion of solid noncircular cross sections, torsion of thinwalled members, bidirectional bending of unsymmetric cross sections, shear flow in and shear center of thin walled multi-celled members, and buckling and stability of columns.
Recommended background: stress (ES 2502) or equivalent.

ME 3820. COMPUTER-AIDED MANUFACTURING.
Cat. I
This introductory course in modern control systems will give students an understanding of the basic techniques, and the range of equipment used in most computer controlled manufacturing operations. The class work is reinforced by hands-on laboratories in the Robotics/CAM lab. Modeling and analysis of machining processes, and applications of PLC (programmable logic control) are included.
Class topics include: Manufacturing Automation, Microcomputers for Process Monitoring and Control, Computer Numerical Control, Switching Theory and Ladder Logic, Transducers and Signal Conditioning, and Closed Loop Digital Control. The laboratories allow students to program and implement several types of the controllers, and will provide an introduction to the topic of industrial robotics.
Recommended background: manufacturing (ME 1800), materials processing (ME 2820), elementary computer/logic device programming.

ME 3901. ENGINEERING EXPERIMENTATION.
Cat. I
A course designed to develop analytical and experimental skills in modern engineering measurement methods, based on electronic instrumentation and computer-based data acquisition systems. The lectures are concerned with the engineering analysis and design as well as the principles of instrumentation, whereas the laboratory periods afford the student an opportunity to use modern devices in actual experiments.
Lecture topics include: review of engineering fundamentals and, among others, discussions of standards, measurement and sensing devices, experiment planning, data acquisition, analysis of experimental data, and report writing. The laboratory experiments address both mechanical and thermal systems and instrumentation in either traditional mechanical engineering (heat transfer, flow measurement/visualization, force/torque/strain measurement, motion/vibration measurement) or materials engineering (temperature and pressure measurements in materials processing, measurement of strain and position in mechanical testing of materials). Each year students will be notified which type of experiments will be used in each term offering. Students may also consult with their academic advisor or the Mechanical Engineering department office.

ME 4320. ADVANCED ENGINEERING DESIGN.
Cat. I
This course integrates students’ background in ME in a one-term design project that is usually taken from a local company. Students must organize themselves and the project to successfully realize a product that meets customer needs. Activities include problem definition, design analysis, mathematical modelling, CAD modelling, manufacturing, testing, liaison to vendors, customer relations, marketing, technical management, purchasing, report writing, and oral presentations.
Recommended background: mechanisms (ME 3310, ME 3311), stress analysis (ES 3502), design (ME 3520), thermo-fluids (ES 3001, ES 3003, ES 3004), materials (ES 2001), manufacturing (ME 1800).

MECHANICAL ENGINEERING COURSES
ME/RBE 4322. MODELING AND ANALYSIS OF MECHATRONIC SYSTEMS.
Cat. I
This course introduces students to the modeling and analysis of mechatronic systems. Creation of dynamic models and analysis of model response using the bond graph modeling language are emphasized. Lecture topics include energy storage and dissipation elements, transducers, transformers, formulation of equations for dynamic systems, time response of linear systems, and system control through open and closed feedback loops. Computers are used extensively for system modeling, analysis, and control. Hands-on projects will include the reverse engineering and modeling of various physical systems. Physical models may sometimes also be built and tested.
Recommended background: mathematics (MA 2051, MA 2071), fluids (ES 3004), thermodynamics (ES 3001), mechanics (ES 2501, ES 2503)

ME 4429. THERMOFLUID APPLICATION AND DESIGN.
Cat. I
This course integrates thermodynamics, fluid mechanics and heat transfer through the use of design projects involving modern technologies, such as electronic cooling, vapor compression power cycles, and turbines. Activities include problem definition, design creation and analysis, mathematical modeling, cost analysis and optimization.
Recommended background: thermofluids (ES 3001, ES 3003, ES 3004) and an introduction to design.

ME 4430. INTEGRATED THERMOELECTRIC DESIGN AND ANALYSIS.
Cat. II
Current state-of-the-art computer based methodologies used in the design and analysis of thermoelectrical systems will be presented and illustrated by selected laboratory demonstrations, and used in projects. Projects will include thermal, mechanical, electronic, and photonic loads of steady state and dynamic nature and will integrate design, analysis, and testing. Students will prepare a technical report and present their results. Topics will include, but not be limited to, thermoelectricity of fiber optic telecommunication cables, high-energy beam interactions with materials, shape memory alloys, microelectronics, MEMS and mechatronics.
Recommended background: MA 2051, ES 2001, ES 2052, ES 3003, ECE 3601, ME 3901, and an introduction to design.
This course will be offered in 2012-13 and in alternating years thereafter.

ME/BME 4504. BIOMECHANICS.
Cat. II
This course emphasizes the applications of mechanics to describe the material properties of living tissues. It is concerned with the description and measurements of these properties as related to their physiological functions. Emphasis on the interrelationships between biomechanics and physiology in medicine, surgery, body injury and protheses.
Topics covered include: review of basic mechanics, stress, strain, constitutive equations and the field equations, viscoelastic behavior, and models of material behavior. The measurement and characterization of properties of tendons, skin, muscles and bone. Biomechanics as related to body injury and the design of prosthetic devices.
Recommended background: mechanics (ES 2501, ES 2502, ES 2503, ME 3501), mathematics (MA 2051).
This course will be offered in 2011-12 and in alternating years thereafter.

ME 4505. ADVANCED DYNAMICS.
Cat. II
This course completes a sequence of sophomore, junior and senior courses in Dynamic Systems, i.e., ES 2503, ME 3505, and ME 4505, which are essential in an undergraduate Mechanical Engineering curriculum. An advanced course intended to emphasize the development and applications of dynamics in three-dimensional space. Problem solutions emphasize the use of vector algebra, matrix methods and differential equations with a goal of developing the student's ability to translate physical problems into mathematical models.
Topics covered include: three-dimensional kinematics using rotating and stationary frames of reference, development of force, energy and momentum equations governing general particle and rigid body systems. Applications of equations to rigid, elastic, and fluid problems.
Recommended background: dynamics (ES 2503).
This course will be offered in 2012-13 and in alternating years thereafter.

ME 4506. MECHANICAL VIBRATIONS.
Cat. I
This course is an introduction to the fundamental concepts of mechanical vibrations, which are important for design and analysis of mechanical and structural systems subjected to time-varying loads. The objective of the course is to expose the students to mathematical modeling and analysis of such systems. Topics covered include: formulation of the equations of motion using Newton's Laws, D'Alembert's Principle and energy methods, prediction of natural frequency for single-degree-of-freedom systems; modeling stiffness characteristics, damping and other vibrational properties of mechanical systems; basic solution techniques by frequency response analysis and convolution integral methods. Examples may include analysis and design for transient passage through resonance, analysis and design of vibration measurement devices; introductory rotordynamics. The course is mainly focused on analysis of single-degree-of-freedom systems, however a basic introduction into multidegree-of-freedom systems is also presented. Computer-based project may be suggested.
Recommended background: Ordinary Differential Equations (MA 2501), Statics (ES 2501), Dynamics (ES 2503).

ME 4512. INTRODUCTION TO THE FINITE ELEMENT METHOD.
Cat. I
This course serves as an introduction to finite element analysis (FEA) for stress analysis problems. Finite element equations are developed for several element types from stiffness and energy approaches and used to solve simple problems. Element types considered include spring, truss, beam, two-dimensional (plane stress/strain and axisymmetric solid), three-dimensional and plates. Stress concentrations, static failures, and fatigue failures are considered for each element type. Emphasis will be placed on knowing the behavior and usage of each element type, being able to select a suitable finite element model for a given problem, and being able to interpret and evaluate the solution quality. A commercial, general-purpose finite element computer program is used to solve problems that are more complex. Projects are used to introduce the use of FEA in the iterative design process.
Recommended background: Mathematics (MA 2051, MA 2071), Mechanics (ES2501 & ES 2502 or CE2000 & CE2001).

ME/BME 4606. BIOFLUIDS.
Cat. II
This course emphasizes the applications of fluid mechanics to biological problems. The course concentrates primarily on the human circulatory and respiratory systems. Topics covered include: blood flow in the heart, arteries, veins and microcirculation and air flow in the lungs and airways. Mass transfer across the walls of these systems is also presented.
Recommended background: continuum mechanics (ME 3501), fluids (ES 3004).
This course will be offered in 2012-13 and in alternating years thereafter.

ME 4710. GAS TURBINES FOR PROPULSION AND POWER GENERATION.
Cat. I
This course provides a study of open-cycle and closed-cycle gas turbines. Topics covered include: thermodynamic cycles and fluid dynamics of airbreathing gas turbines (turbojets, turboprops, ramjets, and scramjets); thermodynamic cycles and fluid dynamics of closed-cycle gas turbines. Performance of specific engine components such as inlets, combustors, nozzles, as well as axial compressors and turbines will be addressed.
Recommended background: compressible fluid dynamics (ME 3410 or equivalent).

ME 4713. SPACECRAFT DYNAMICS AND CONTROL.
Cat. I
This course covers broad topics in spacecraft attitude dynamics, stability and control. The course includes a review of particle and two-body dynamics and introduction to rigid body dynamics. Orbital and attitude maneuvers are presented. Attitude control devices and momentum exchange techniques such as spinners, dual spinners, gravity gradient, and geomagnetic torques are presented. Attitude sensors/actuators are presented and the attitude control problem is introduced. Gyroscopic instruments are introduced and demonstrated in the laboratory. Open-loop stability analysis for a variety of equilibrium conditions is discussed. Control using momentum exchange and mass expulsion (thrusters) devices is discussed.
Recommended background: astronautics (ME 2713 or equivalent), dynamics (ES 2503, PH 2201 or equivalent).
ME 4718. ADVANCED MATERIALS WITH AEROSPACE APPLICATIONS.
Cat. I
This course covers topics on the design, fabrication and behavior of advanced materials used in structural and propulsion components of aerospace vehicles. The design, fabrication, and properties of polymer, metal and ceramic matrix composites used in aerospace structures are presented. The fabrication and behavior of aluminum and titanium alloys used in propulsion components as well as the processing and performance of Nickel-based superalloys are also presented. The fundamentals of coatings for high temperature oxidation, hot corrosion, and thermal protection are introduced.
Recommended background: Introduction to Materials Science (ES 2001), Stress Analysis (ES 2502) or equivalent.

ME 4719. ROCKET PROPULSION.
Cat. I
This course provides a study of rocket propulsion systems for launch vehicles and spacecraft. Dynamics, performance and optimization of rocket-propelled vehicles are presented. Performance and component analysis of chemical and electric propulsion systems are covered. Advanced propulsion and micropulsion concepts are introduced. Additional topics may include propellant storage, feed systems, propulsion system integration, and environmental impacts of propulsion systems.
Recommended background: compressible fluid dynamics (ME 3410 or equivalent).

ME 4723. AIRCRAFT DYNAMICS AND CONTROL.
Cat. I
The goal of this course is for students to develop, analyze, and utilize models of aircraft dynamics, and to study various aircraft control systems. Topics include: review of linear systems, longitudinal and lateral flight dynamics, simulation methodologies, natural modes of motion, static and dynamic aircraft stability, and aircraft control systems (such as autopilot design, flight path control, and automatic landing). Other topics may include: vertical take-off and landing (VTOL) vehicles and rotorcraft.
Recommended background: dynamics (ES2503, PH 2201 or equivalent).

ME 4733. GUIDANCE, NAVIGATION AND COMMUNICATION.
Cat. I
This course broadly covers methods and current enabling technologies in the analysis, synthesis and practice of aerospace guidance, navigation, and communication and information systems. Topics covered include: position fixing and celestial navigation with redundant measurements, recursive navigation, and Kalman filtering; inertial navigation systems, global position systems, and Doppler navigation; orbit determination; atmospheric re-entry; communication architectures, data rates, and communication link design; tropospheric and ionospheric effects on radio-wave propagation; pursuit guidance and ballistic flight.
Recommended background: controls (ES 3011 or equivalent).

ME 4770. AIRCRAFT DESIGN.
Cat. I
This course introduces students to design of aircraft systems. Students complete a conceptual design of an aircraft in a term-long project. Students are exposed to the aircraft design process, and must establish design specifications, develop and analyze alternative designs, and optimize their designs to meet mission requirements. Students work together in teams to apply material learned in the areas of aerodynamics, structures and materials, propulsion, stability and control, and flight mechanics and maneuvers to the preliminary design of an aircraft. The project requirements are selected to reflect real-life aircraft mission requirements, and teams are required to design systems which incorporate appropriate engineering standards and multiple realistic constraints. The teams will present their design in a final report and oral presentation.
Recommended background: fluid dynamics (ES 5004), stress analysis (ES 2503).

ME 4771. SPACECRAFT AND MISSION DESIGN.
Cat. I
This course introduces students to design of spacecraft and missions. Students are introduced to the process of designing a spacecraft and major subsystems to meet a specific set of objectives or needs. In addition, students will learn about different spacecraft subsystems and what factors drive their design. Particular emphasis is given to propulsion, power, attitude control, structural and thermal control subsystems. Students work together in teams to apply material learned in the areas of orbital mechanics, space environments, attitude determination and control, space structures, and propulsion to the preliminary design of a spacecraft and mission. The project requirements are selected to reflect real-life missions, and teams are required to design systems which incorporate appropriate engineering standards and multiple realistic constraints. The teams will present their design in a final report and oral presentation.
Recommended background: astronautics (ME 2713).

ME 4810. AUTOMOTIVE MATERIALS AND PROCESS DESIGN.
Cat. II
This course focuses on materials used in the automotive industry. Students complete a term-long project that integrates design, materials selection and processing considerations. Activities include: problem definition, development of design specifications, development and analysis of alternative designs, conceptual designs and materials and process selection. Students will consider cost, and environmental impact of alternative material choices. Students will present their results in intermediate and final design reviews.
Recommended background: materials science (ES 2001), stress analysis (ES 2502), or equivalent.
This course will be offered in 2012-13 and in alternating years thereafter.

ME 4813. CERAMICS AND GLASSES FOR ENGINEERING APPLICATIONS.
Cat. II
This course develops an understanding of the processing, structure, property, performance relationships in crystalline and vitreous ceramics. The topics covered include crystal structure, glassy structure, phase diagrams, microstructures, mechanical properties, optical properties, thermal properties, and materials selection for ceramic materials. In addition the methods for processing ceramics for a variety of products will be included.
Recommended Background: ES 2001 or equivalent.
This course will be offered in 2012-13 and in alternating years thereafter.

ME/BME 4814. BIOMATERIALS.
Cat. I
A course specializing in material selection and special problems associated with biomedical engineering.
Topics covered include: fundamentals of metals, plastics, and ceramics and how they can be applied to biomedical applications. Case histories of successful and unsuccessful material selections. Current literature is the primary source of material.
Recommended background: materials (ES 2001).

ME/RE 4815. INDUSTRIAL ROBOTICS.
Cat. I
This course introduces students to robotics within manufacturing systems. Topics include: classification of robots, robot kinematics, motion generation and transmission, end effectors, motion accuracy, sensors, robot control and automation. This course is a combination of lecture, laboratory and project work, and utilizes industrial robots. Through the laboratory work, students will become familiar with robotic programming (using a robotic programming language VAL II) and the robotic teaching mode. The experimental component of the laboratory exercise measures the motion and positioning capabilities of robots as a function of several robotic variables and levels, and it includes the use of experimental design techniques and analysis of variance.
Recommended background: manufacturing (ME 1800), kinematics (ME 3310), control (ES 3011), and computer programming.

ME 4821. PLASTICS.
Cat. II
This course develops the processing, structure, property, performance relationships in plastic materials. The topics covered include polymerization processes, chain structure and configuration, molecular weights and distributions, amorphous and crystalline states and glass-rubber transition. The principles of various processing techniques including injection molding, extrusion, blow molding, thermoforming and calendaring will be discussed. The physical and mechanical properties of polymers and polymer melts will be described with specific attention to rheology and viscoelasticity. Pertinent issues related to environmental degradation and recyclability will be highlighted.
Recommended Background: ES2001 or equivalent.
This course will be offered in 2011-12 and in alternating years thereafter.
ME 4832. CORROSION AND CORROSION CONTROL.
Cat. II
An introductory course designed to acquaint the student with the different forms of corrosion and the fundamentals of oxidation and electro-chemical corrosion.

Topics covered include: corrosion principles, environmental effects, metallurgical aspects, galvanic corrosion, crevice corrosion, pitting, intergranular corrosion, erosion corrosion, stress corrosion, cracking and hydrogen embrittlement, corrosion testing, corrosion prevention, oxidation and other high-temperature metal-gas reactions.

Recommended background: materials (ES 2001).
This course will be offered in 2011-12 and in alternating years thereafter.

ME 4840. PHYSICAL METALLURGY.
Cat. I
Fundamental relationships between the structure and properties of engineering materials are studied. Principles of diffusion and phase transformation are applied to the strengthening of commercial alloy systems. Role of crystal lattice defects on material properties and fracture are presented.
Strongly recommended as a senior-graduate level course for students interested in pursuing a graduate program in materials or materials engineering at WPI, or other schools.
Recommended background: materials (ES 2001, ME 2820).

ME 4860. FOOD ENGINEERING.
Cat II
An introductory course on the structure, processing, and properties of food.

Topics covered include: food structure and rheology, plant and animal tissues, texture, glass transition, gels, emulsions, micelles, food additives, food coloring, starches, baked goods, mechanical properties, elasticity, viscoelastic nature of food products, characteristics of food powders, fat eutectics, freezing and cooking of food, manufacturing processes, cereal processing, chocolate manufacture, microbial growth, fermentation, transport phenomena in food processing, kinetics, preserving and packaging of food, testing of food.

Recommended Background: ES2001 or equivalent.
This course will be offered in 2012-13 and in alternating years thereafter.

ME 4875/ME575. INTRODUCTION TO NANOMATERIALS AND NANOTECHNOLOGY.
Cat. I
This course introduces students to current developments in nanoscale science and technology. The current advance of materials and devices consisting of building blocks of metals, semiconductors, ceramics or polymers that are nanometer size (1-100 nm) are reviewed. The profound implications for technology and science of this research field are discussed. The differences of the properties of matter on the nanometer scale from those on the macroscopic scale due to the size confinement, predominance of interfacial phenomena and quantum mechanics are studied. The main issues and techniques relevant to science and technologies on the nanometer scale are considered. New developments in this field and future perspectives are presented. Topics covered include: fabrication of nanoscale structures, characterization at nanoscale, molecular electronics, nanoscale mechanics, new architecture, nano-optics and societal impacts.
Recommended background: ES 2001 Introduction to Materials or equivalent

IS/P. SPECIAL TOPICS.
Cat. I
For students who wish to pursue in depth various mechanical engineering topics. Topics covered include: theoretical or experimental studies in subjects of interest to mechanical engineers.
Registration as a junior or senior is assumed.

MILITARY SCIENCE

The intent of the Military Science program of courses is that they be taken in sequential order. Any student who wishes to depart from this recommendation must consult with the Military Science department head.
ML 1011 and ML 1021 will appear on the WPI transcript as a zero credit course with a grade. Successful completion of ML 1011 and ML 1012 earns 1/9 unit in ML 1012. Successful completion of ML 1021 and ML 1022 earns 1/9 unit in ML 1022.

ML 1011. FOUNDATIONS OF OFFICERSHIP I.
Cat. I (0 units w/grade)
Introduction to issues and competencies that are central to a commissioned officer’s responsibilities. Establishes a framework for understanding officership, leadership, and Army values. Additionally, the semester addresses “life skills” including fitness and time management.
Participation in leadership laboratories and participation in off-campus training sessions (field training exercise) is also required.

ML 1012. FOUNDATIONS OF OFFICERSHIP II.
Cat. I (1/9 units after completion of 1011 and 1012)
This course continues the studies begun in ML 1011. Students make oral presentations on the elements of leadership, enhancing effective communication.
Students begin to develop leadership potential by instilling self-confidence and fostering teamwork through basic survival techniques (e.g., water survival).
Participation in leadership laboratories and participation in off-campus training sessions (field training exercise) is also required.

ML 1021. BASIC LEADERSHIP I.
Cat. I (0 units w/grade)
ML 1021 expands upon the fundamentals introduced in the previous term by focusing on communications, leadership, and problem solving. “Life skills” lessons in this semester include: problem solving, goal setting, interpersonal communication skills, and assertiveness skills.
Participation in leadership laboratories and participation in off-campus training sessions (field training exercise) is also required.

ML 1022. BASIC LEADERSHIP II.
Cat. I (1/9 units after completion of 1021 and 1022)
ML 1022 continues by providing cadets with interesting lessons yielding immediately useful skills. The course also gives accurate information about life in the Army, including the organization of the Army, employment benefits, and work experiences of junior officers.

ML 2011. INDIVIDUAL LEADERSHIP STUDIES I.
Cat. I (1/12 unit)
Introduces students to team building techniques. Students build upon the basic leader principals and leadership development methodologies to refine their understanding of leadership. How to build teams, how to influence, how to communicate, how and when to make decision, and creative problem-solving.
Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required.
Recommended background: ML 1022.

ML 2012. INDIVIDUAL LEADERSHIP STUDIES II.
Cat. I (1/12 unit)
The curriculum focuses on building character. Where years one, three and four focus on mastering definitions, concepts, ideas and principles, year two focuses on direct, physical experiences. Year two centers on giving cadets the opportunity to apply, practice and experience leadership principles. Cadets are asked to reflect upon their actions and those of others.
Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required.
Recommended background: ML 2011

ML 2021. LEADERSHIP AND TEAMWORK I.
Cat. I (1/12 unit)
Students continue the study of leader principals and are introduced to formal policies such as equal opportunity, ethics, and values. Military communication skills are trained along with the principles of camouflage. Complex cases of risk management are studied. Students will submit a written information paper.
Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required.
Recommended background: ML 2012
ML 2022. LEADERSHIP AND TEAMWORK II.
Cat. I (1/12 unit)
This course covers small unit movement and military tactics. It combines previous study in weapons, movement and communications to teach the combination of firepower and maneuver to the student. This course also teaches the student the elements of how the military trains its personnel. A written decision paper and practical exercise in conducting training is included in this course. Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required.
Recommended background: ML 2021

ML 2091. LEADERSHIP TRAINING COURSE.
Cat. I (1/6 unit)
LTC puts each cadet through 24 days of pushing themselves to the mental and physical limits, while enhancing leadership, problem solving and teamwork skills. Cadets are put through extensive leadership training, which includes leadership reaction scenarios; Land Navigation exercises, first aid training. Cadets must pass the Army Fitness Test (APFT) in order to graduate.

ML 3011. LEADERSHIP AND ETHICS I.
Cat. I (1/6 unit)
This course focuses on development of individual leadership abilities. This course reviews leadership styles, management strategies and training techniques for leaders of small units. Promoting and developing communication skills and teamwork are addressed. Examines leadership of small units conducting conventional combat operations and tactical employment of weapon systems. Development of oral communication skills through military briefings and issuance of operations orders. Special attention is placed on evaluations through practical exercises. Participation in leadership labs and participation in an off-campus training session (field training exercise) is also required.
Recommended background: Students must have completed the basic course or ROTC Leadership Training course and have signed a personal contract with the US Army. Department Head approval is required.

ML 3012. LEADERSHIP AND PROBLEM SOLVING I.
Cat. I (1/6 unit)
Student learns how to conduct crisis planning and management. Discussion of roles and functions of combat arms, combat support, and combat service support branches. Case studies of small-unit operations are studied. Introduction to Army special operations, military operations other than war, and trends in the military. Students write self-evaluations throughout this course. Students are graded on their performance during leadership practical exercises. Attendance at monthly labs and formal social functions is required. Students write self-evaluations through this course. Students are graded on their performance during leadership practical exercises.
Recommended background: ML 3011

ML 3021. LEADERSHIP AND ETHICS II.
Cat. I (1/6 unit)
ML 3021 is designed to continue the development as leaders by presenting instruction in the three foundational areas of leadership, interpersonal communication, and values and ethics. The leadership module contains an examination of Army leadership doctrine followed by expansion on key leadership concepts and provide feedback for cadet leadership self-development efforts.

ML 3022. LEADERSHIP AND ETHICS II.
Cat. I (1/6 unit)
The main thrust of the communication module is the opportunity for cadets to present an information briefing and receive feedback from both instructor and fellow students. The last module of the term contains lessons that focus on values, ethics, ethical decision-making, consideration of others, and spiritual needs. Attendance at monthly labs, attendance at formal social functions and an off-campus weekend leadership exercise is required.
Recommended background: ML 3021

ML 3023. LEADERSHIP DEVELOPMENT AND ASSESSMENT COURSE.
Cat. I (1/6 unit)
LDAC puts each cadet through 32 days of intensive individual, squad and platoon-level training to assess his/her leadership potential. Each cadet is measured against 23 leadership dimensions in such subjects as physical stamina, technical competence, delegation, decisiveness, problem analysis and the several Army values, among others. Instruction and evaluation at LDAC is progressive, building skills in individual subjects like the Army Physical Fitness Test, basic military skills and land navigation, followed by such skill-building exercises as Individual Tactical Training.

ML 4011. LEADERSHIP AND MANAGEMENT I.
Cat. I (1/6 unit)
ML 4011 begins with a series of lessons designed to enable the cadets to make informed career decisions as they prepare their accessions documents. Lessons concentrate on Army operations and training management, communications and leadership skills and support the beginning of the final transition from cadet to lieutenant. The course focuses cadets, early in the year, on attaining knowledge and proficiency in several critical areas they will need to operate effectively as Army officers. These areas include: the Army's training management system, coordinating activities with staffs, and counseling skills. While the proficiency attained in each of these areas will initially be at the apprentice level, cadets will continue to sharpen these skills as they perform their roles as cadet officers in the ROTC battalion and as new lieutenants after commissioning. At the end of this semester cadets should possess the fundamental skills, attributes, and abilities to operate as competent leaders in the cadet battalion and confidently shoulder the responsibilities entrusted to them.

ML 4022. LEADERSHIP AND MANAGEMENT II.
Cat. I (1/6 unit)
This Course focuses on completing the transition from cadet to lieutenant. As an expansion of the Ethics instruction in ML 3021, the course starts with an examination of unit ethical climate and the commander's role as the moral anchor of the unit. This is followed by a module addressing military law and leadership. The next module reinforces previous instruction on the organization of the Army and introduces how the Army organizes for operations from the tactical to strategic level. This is followed by instruction on administrative and logistical management that focuses on the fundamentals of soldier and unit level support. Next is a short module that focuses on preparing cadets for their forthcoming commissioning and military service. At the core of this semester is the Advanced Course's Capstone Exercise. This twelve-lesson exercise directly reinforces all modules from this term, and also incorporates and reinforces many learning objectives from modules throughout the entire curriculum. The Capstone Exercise requires cadets, both individually and collectively, to apply their knowledge to solve problems and confront situations commonly faced by junior officers. Upon completion of this course the cadets will be prepared to shoulder the responsibility of being a commissioned officer in the United States Army.

ML 4023. OFFICERSHIP.
Cat. I (1/6 unit)
This course is a continuation of ML 4022.

ML 4024. TRANSITION TO LIEUTENANT.
Cat. I (1/6 unit)
Cadets organize and lead all the junior cadets. This course covers the military legal system, personnel actions and personal finances. It certifies fundamental competencies in land navigation, tactics, counseling, and interpersonal communications. This course requires three hours of class work and three hours of physical fitness per week. Three lab exercises and a formal military ball are required.
Recommended background: ML 4023
PHYSICAL EDUCATION COURSES

PE 1001. INTRO TO GOLF & TENNIS.
Cat. I (1/12 unit)
Introduction to the sports through skill development and play.

PE 1002. INTRO TO VOLLEYBALL & SQUASH.
Cat. I (1/12 unit)
Introduction to the sports through skill development and play.

PE 1003. INTRO TO BOWLING & BADMINTON.
Cat. I (1/12 unit)
Introduction to the sports through skill development and play.

PE 1004. INTRO TO TABLE TENNIS, GOLF, & TENNIS.
Cat. I (1/12 unit)
Introduction to the sports through skill development and play.

PE 1005. INTRO TO RECREATIONAL SPORTS.
Cat. I (1/12 unit)
This summer course introduces students to various sports through skill development and play. Possible sports taught include badminton, bowling, golf, racquetball, squash, swimming, table tennis, tennis, and volleyball.

PE 1006. WELLNESS.
Cat. I (1/12 unit)
Introductory course designed to acquaint students with knowledge and skills necessary to make choices that foster health and well-being.

PE 1007. BASIC WATER SAFETY.
Cat. I (1/12 unit)
For the intermediate to advanced swimmer only. Students will learn about water recreational activities and how to remain safe while participating in them. Opportunity to learn the necessary means for safety in/near water and basic rescue techniques.

PE 1008. ROWING FOR FITNESS.
Cat. I
This course will teach basic rowing training techniques and principles with the goal for students to develop and implement an individualized conditioning program for themselves. All classes will be conducted on-campus through the use of rowing machines located in Alumni Gym.

PE 1009. WALKING FOR FITNESS.
Cat. I
This course will teach basic walking techniques and principles with the goal for students to develop and implement an individualized conditioning program for themselves.

PE 1011. TOUCH FOOTBALL.
Cat. I (1/12 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1012. BASKETBALL.
Cat. I (1/12 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1013. SOFTBALL.
Cat. I (1/12 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1014. TENNIS.
Cat. I (1/12 unit)
Instruction will focus on basic strokes and techniques. Rules, strategy and play will be integrated as students' skills develop.

PE 1015. BADMINTON & TABLE TENNIS.
Cat. I (1/12 unit)
Instruction will focus on basic strokes and techniques. Rules, strategy and play will be integrated as students' skills develop.

PE 1016. SQUASH & RACQUETBALL.
Cat. I (1/12 unit)
Instruction will focus on basic strokes and techniques. Rules, strategy and play will be integrated as students' skills develop.

PE 1017. BEGINNING SWIMMING.
Cat. I (1/12 unit)
For the non-swimmer. Students will receive instruction in basic survival skills and the primary techniques to learn to swim safely.

PE 1018. CO-ED VOLLEYBALL.
Cat. I (1/12 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1019. SOCCER.
Cat. I
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1021. BOWLING.
Cat. I (1/12 unit)
Introductory course designed to acquaint students with the basic skills, knowledge and practical experience.

PE 1055. PHYSICAL CONDITIONING.
Cat. I (1/12 unit)
This course will teach basic strength training principles and techniques. Students will develop and implement an individualized conditioning program.

PE 1056. LIFEGUARDING I.
Cat. I (1/12 unit)
This class is based on the Red Cross Manual for Lifeguarding. Red Cross fee and books are required. The Lifeguard I course is the first part of a two course requirement (Lifeguarding I and II) for a student to be certified in CPR for the Professional Rescuer, First Aid, AED, Oxygen Administration and Lifeguarding. Recommended background: PE 1007.

PE 1057. LIFEGUARDING II.
Cat. I (1/12 unit)
This class is based on the Red Cross Manual for Lifeguarding. Red Cross fee and books are required. The Lifeguard I course is the first part of a two course requirement (Lifeguarding I and II) for a student to be certified in CPR for the Professional Rescuer, First Aid, AED, Oxygen Administration and Lifeguarding. Recommended background: PE 1007.

PE 1059. WEIGHT TRAINING PROGRAM FOR WOMEN.
Cat. I (1/12 unit)
This introductory course is designed to acquaint women with circuit training and free weight programs.

PE 1070. LEISURE EDUCATION: REDEFINING SOCIAL NORMS.
Cat. I (1/12 unit)
Introductory course designed to explore various leisure education alternatives.

PE 1077. SWIMMING FOR FITNESS.
Cat. I (1/12 unit)
For the intermediate to advanced swimmer. This class is geared toward swimming for fitness purposes. Workouts will be administered each class period with students developing the knowledge to create workouts for themselves.

PE 1078. AQUATIC CONDITIONING.
Cat. I
This course will teach aquatic conditioning (aerobics, walking, strength and interval training) with the goal for students to develop and implement an individualized conditioning program for themselves. For the intermediate and advanced swimmer. All classes will be conducted on-campus through the use of the pool located in Alumni Gym.

PE 1100. SERIES.
Cat. I (1/12 unit)
Credit for activity in one of three categories: 1) WPI athletic team participation, 2) club sports, 3) approved courses not offered at WPI.
PHYSICS COURSES

PHYSICS

The second digit in physics course numbers is coded as follows.

1 — General physics
2 — Theoretical mechanics, statistical physics, kinetic theory, etc.
3 — Electricity and magnetism, electromagnetic theory
4 — Quantum mechanics
5 — Particular topics
6 — Laboratory

INTRODUCTORY PHYSICS SEQUENCE

There are four course topics in the introductory physics sequence. The four topics are Classical Mechanics (PH 1110/PH 1111), Electricity and Magnetism (PH 1120/PH 1121), 20th Century Physics (PH 1130), and Oscillations and Waves (PH 1140). Each course includes a laboratory component.

Students should take either PH 1110 or PH 1111, but not both; similarly, either PH 1120 or PH 1121, but not both. The primary difference between the PH 1110-PH 1120 option and PH 1111-PH 1121 is that the material in PH 1111-PH 1121 is treated somewhat more formally and rigorously than in PH 1110-PH 1120, thus presuming a better-than-average mathematics background. The recommended mathematics background for each course is indicated in the respective course description and should be considered carefully in each case.

Because the topics covered in the two mechanics and in the two electricity and magnetism courses are the same, it is possible to cross over from one sequence to the other. For example, PH 1120 could be taken after PH 1111, or, upon consulting with the course instructor, PH 1121 could be taken after successful completion of PH 1110. Finally, it should be noted that any combination of the first two introductory courses provides adequate preparation for both of the remaining courses in 20th Century Physics (PH 1130), and Oscillations and Waves (PH 1140).

The courses in classical mechanics and electricity and magnetism are regarded as essential preparation for many fundamental engineering courses as well as for further work in physics. PH 1130 gives a first introduction to 20th century physics and is designed to provide a context for the appreciation of present-day advances in physics and high-technology applications. PH 1140 deals in depth with oscillating systems, a topic area of fundamental importance in physics, and whose engineering applications span the range from electromagnetic oscillations to the mechanical vibrations of machinery and structures.

PH 1110. GENERAL PHYSICS—MECHANICS.

Cat. I

Introductory course in Newtonian mechanics.

Topics include: kinematics of motion, vectors, Newton's laws, friction, work-energy, impulse-momentum, for both translational and rotational motion.

Recommended background: concurrent study of MA 1021.

Students may not receive credit for both PH 1110 and PH 1111.

PH 1111. PRINCIPLES OF PHYSICS—MECHANICS.

Cat. I

An introductory course in Newtonian mechanics that stresses invariance principles and the associated conservation laws.

Topics include: kinematics of motion, vectors and their application to physical problems, dynamics of particles and rigid bodies, energy and momentum conservation, rotational motion.

Recommended background: concurrent study of MA 1023 (or higher).

Students with limited prior college-level calculus preparation are advised to take PH 1110.

Students may not receive credit for both PH 1111 and PH 1110.

PH 1120. GENERAL PHYSICS—ELECTRICITY AND MAGNETISM.

Cat. I

An introduction to the theory of electricity and magnetism.

Topics include: Coulomb's law, electric and magnetic fields, capacitance, electrical current and resistance, and electromagnetic induction.

Recommended background: working knowledge of the material presented in PH 1110 or PH 1111 and concurrent study of MA 1022.

Students may not receive credit for both PH 1120 and PH 1121.

PH 1121. PRINCIPLES OF PHYSICS—ELECTRICITY AND MAGNETISM.

Cat. I

An introduction to electricity and magnetism, at a somewhat higher mathematical level than PH 1120.

Topics include: Coulomb's Law, electric fields and potentials, capacitance, electric current and resistance, magnetism, and electromagnetic induction.

Recommended background: working knowledge of material covered in PH 1111 and concurrent study of MA 1024 (or higher). Students concurrently taking MA 1022 or MA 1023 are advised to take PH 1120.

Students may not receive credit for both PH 1121 and PH 1120.

PH 1130. INTRODUCTION TO 20TH CENTURY PHYSICS.

Cat. I

An introduction to the pivotal ideas and developments of twentieth-century physics.

Topics include: special relativity, photoelectric effect, X-rays, Compton scattering, blackbody radiation, De Broglie waves, uncertainty principle, Bohr theory of the atom, atomic nuclei, radioactivity, and elementary particles.

Recommended background: familiarity with material covered in PH 1110 and PH 1120 (or PH 1111 and PH 1121) and completion of MA 1021 and MA 1022.

PH 1140. OSCILLATIONS, AND WAVES.

Cat. I

An introduction to oscillating systems and waves.

Topics include: free, clamped forced, and coupled oscillations of physical systems, traveling waves and wave packets, reflection, and interference phenomena.

Recommended background: working knowledge of the material covered in PH 1110 and PH 1120 (or PH 1111 and PH 1121) and completion of MA 1021, MA 1022 and MA 1023.

PH 2201. INTERMEDIATE MECHANICS I.

Cat. I

This course emphasizes a systematic approach to the mathematical formulation of mechanics problems and to the physical interpretation of the mathematical solutions.

Topics covered include: Newton's laws of motion, kinematics and dynamics of a single particle, vector analysis, motion of particles, rigid body rotation about an axis.

Recommended background: PH 1110, PH 1120, PH 1130, PH 1140, MA 1021, MA 1022, MA 1023, MA 1024 and concurrent registration in or completion of MA 2051.

PH 2202. INTERMEDIATE MECHANICS II.

Cat. I

This course is a continuation of the treatment of mechanics started in PH 2201.

Topics covered include: rigid-body dynamics, rotating coordinate systems, Newton's law of gravitation, central-force problem, driven harmonic oscillator, an introduction to generalized coordinates, and the Lagrangian and Hamiltonian formulation of mechanics.

PH 2301. ELECTROMAGNETIC FIELDS.

Cat. I

Introduction to the theory and application of electromagnetic fields, appropriate as a basis for further study in electromagnetism, optics, and solid-state physics.

Topics include: electric field produced by charge distributions, electrostatic potential, electrostatic energy, magnetic force and field produced by currents and by magnetic dipoles, introduction to Maxwell's equations and electromagnetic waves.

Recommended background: introductory electricity and magnetism, vector algebra, integral theorems of vector calculus as covered in MA 2251.

PH 2501. PHOTONICS.

Cat. II

An introduction to the use of optics for transmission and processing of information. The emphasis is on understanding principles underlying practical photonic devices. Topics include lasers, light emitting diodes, optical fiber communications, fiber lasers and fiber amplifiers, planar optical waveguides, light modulators and photodetectors. Recommended background is PH 1110, PH 1120, PH 1130 and PH 1140 (or their equivalents).

This course will be offered in 2012-13 and in alternating years thereafter.
PH 2502. LASERS.
Cat. II
An introduction to the physical principles underlying lasers and their applications. Topics will include the coherent nature of laser light, optical cavities, beam optics, atomic radiation, conditions for laser oscillation, optical amplifiers (including fiber amplifiers), pulsed lasers (Q-switching and mode locking), laser excitation (optical and electrical), and selected laser applications. Recommended background is PH 1110, PH 1120, PH 1130 and PH 1140 (or their equivalents).
This course will be offered in 2011-12 and in alternating years thereafter.

PH 2510. ATOMIC FORCE MICROSCOPY.
Cat. II
Atomic force microscopes (AFMs) are instruments that allow three-dimensional imaging of surfaces with nanometer resolution and are important enabling tools for nanoscience and technology. The student who successfully completes this course will understand the fundamental principles of AFMs, be able to run one, and interpret the data that are collected.
Recommended background: PH 1110 and 1120. Suggested background: PH 1130 and PH 1140.
This course will be offered in 2012-13 and in alternating years thereafter.

PH 2520. INTRODUCTION TO ASTROPHYSICS.
Cat. II
A selective study of components of the universe (the solar system, stars, nebulae, galaxies) and of cosmology, based on astronomical observations analyzed and interpreted through the application of physical principles, and organized with the central purpose of presenting the latest understanding of the nature and evolution of the universe. Some topics to be covered include the Big Bang & Inflation; Stellar Behavior & Evolution; White Dwarfs, Neutron Stars, & Supernovae; Black Holes; Dark Matter & Dark Energy.
Recommended background is PH 1110 (or PH 1111), PH 1120 (or PH 1121), and especially PH 1130.
Suggested background: PH 1140.
This course will be offered in 2011-12 and in alternating years thereafter.

PH 2601. PHOTONICS LABORATORY.
Cat. II
This course provides an experimental approach to concepts covered in Photonics (PH 2501), Lasers (PH 2502), and Optics (PH 3504). Through a series of individually tailored experiments, students will reinforce their knowledge in one or more of these areas, while at the same time gaining exposure to modern photonics laboratory equipment. Experiments available include properties of optical fibers, optical fiber diagnostics, optical communications systems, properties of photodetectors, mode structure and threshold behavior of lasers, coherence properties of laser light, characterization of fiber amplifiers, diffraction of light, polarization of light, interferometry.
Recommended background: PH 1110/1111, PH 1120/1121, PH 1130, PH 1140, and one or more of the courses PH 2501, PH 2502, or PH 3504. No prior laboratory background is expected.
This course will be offered in 2012-13 and in alternating years thereafter.

PH 2651. INTERMEDIATE PHYSICS LABORATORY.
Cat. I
This course offers experience in experimentation and observation for students of the sciences and others. In a series of subject units, students learn or review the physical principles underlying the phenomena to be observed and the basis for the measurement techniques employed. Principles and uses of laboratory instruments including the cathode-ray oscilloscope, meters for frequency, time, electrical and other quantities are stressed. In addition to systematic measurement procedures and data recording, strong emphasis is placed on processing of the data, preparation and interpretation of graphical presentations, and analysis of precision and accuracy, including determination and interpretation of best value, measures of error and uncertainty, linear best fit to data, and identification of systematic and random errors. Preparation of high-quality experiment reports is also emphasized. Representative experiment subjects are: mechanical motions and vibrations; free and driven electrical oscillations; electric fields and potential; magnetic materials and fields; electron beam dynamics; optics; diffraction-grating spectroscopy; radioactive decay and nuclear energy measurements.
Recommended background: the Introductory Physics course sequence or equivalent. No prior laboratory background beyond that experience is required. Students who have received credit for PH 2600 or PH 3600 may not receive credit for PH 2651.

PH 3301. ELECTROMAGNETIC THEORY.
Cat. I
A continuation of PH 2301, this course deals with more advanced subjects in electromagnetism, as well as study of basic subjects with a more advanced level of mathematical analysis. Fundamentals of electric and magnetic fields, dielectric and magnetic properties of matter, quasi-static time-dependent phenomena, and generation and propagation of electromagnetic waves are investigated from the point of view of the classical Maxwell's equations.

PH 3401. QUANTUM MECHANICS I.
Cat. I
This course includes a study of the basic postulates of quantum mechanics, its mathematical language and applications to one-dimensional problems. The course is recommended for physics majors and other students whose future work will involve the application of quantum mechanics.
Topics include wave packets, the uncertainty principle, introduction to operator algebra, application of the Schrodinger equation to the simple harmonic oscillator, barrier penetration and potential wells.
Recommended background: Junior standing, MA 451, and completion of the introductory physics sequence, including the introduction to the 20th century physics.
Suggested background: knowledge (or concurrent study) of linear algebra, Fourier series, and Fourier transforms.

PH 3402. QUANTUM MECHANICS II.
Cat. I
This course represents a continuation of PH 3401 and includes a study of three-dimensional systems and the application of quantum mechanics in selected fields. Topics include: the hydrogen atom, angular momentum, spin, perturbation theory and examples of the application of quantum mechanics in fields such as atomic and molecular physics, solid state physics, optics, and nuclear physics.
Recommended background: PH 3401.

PH 3501. RELATIVITY.
Cat. II
This course is designed to help the student acquire an understanding of the formalism and concepts of relativity as well as its application to physical problems. Topics include the Lorentz transformation, 4-vectors and tensors, covariance of the equations of physics, transformation of electromagnetic fields, particle kinematics and dynamics.
Recommended background: knowledge of mechanics and electrodynamics at the intermediate level.
This course will be offered in 2012-13 and in alternating years thereafter.

PH 3502. SOLID STATE PHYSICS.
Cat. II
An introduction to solid state physics. Topics include: crystallography, lattice vibrations, electron band structure, metals, semiconductors, dielectric and magnetic properties.
Recommended background: prior knowledge of quantum mechanics at an intermediate level.
Suggested background: knowledge of statistical physics is helpful.
This course will be offered in 2012-13 and in alternating years thereafter.

PH 3503. NUCLEAR PHYSICS.
Cat. II
This course is intended to acquaint the student with the measurable properties of nuclei and the principles necessary to perform these measurements. The major part of the course will be an introduction to the theory of nuclei. The principal topics will include binding energy, nuclear models and nuclear reactions. The deutron will be discussed in detail and the nuclear shell model will be treated as well as the nuclear optical model.
Recommended background: some knowledge of the phenomena of modern physics at the level of an introductory physics course and knowledge of intermediate level quantum mechanics.
This course will be offered in 2011-12 and in alternating years thereafter.
PH 3504. OPTICS.
Cat. II
This course provides an introduction to classical physical optics, in particular interference, diffraction and polarization, and to the elementary theory of lenses. The theory covered will be applied in the analysis of one or more modern optical instruments.
Recommended background: knowledge of introductory electricity and magnetism and of differential equations.
Suggested background: PH 2301.
This course will be offered in 2011-12 and in alternating years thereafter.

PH 4201. ADVANCED CLASSICAL MECHANICS.
Cat. I
A review of the basic principles and introduction to advanced methods of mechanics, emphasizing the relationship between dynamical symmetries and conserved quantities, as well as classical mechanics as a background to quantum mechanics.
Topics include: Lagrangian mechanics and the variational principle, central force motion, theory of small oscillations, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi Theory, rigid body motion, and continuous systems.
Recommended background: PH 2201 and PH 2202.
This is a 14-week course.

PH 4206. STATISTICAL PHYSICS.
Cat. I
An introduction to the basic principles of thermodynamics and statistical physics.
Topics covered include: basic ideas of probability theory, statistical description of systems of particles, thermodynamic laws, entropy, microcanonical and canonical ensembles, ideal and real gases, ensembles of weakly interacting spin 1/2 systems.
Recommended background: knowledge of quantum mechanics at the level of PH 3401-3402 and of thermodynamics at the level of ES 3001.

Graduate Physics Courses of Interest to Undergraduates

PH 511/PH 4201. CLASSICAL MECHANICS.

PH 514. QUANTUM MECHANICS I.
Schroedinger wave equation. Harmonic oscillator, hydrogen atom, potential wells, approximation methods.

PH 515. QUANTUM MECHANICS II.

PH 522. THERMODYNAMICS AND STATISTICAL MECHANICS.
Quantum concepts applied to thermodynamics. Bose-Einstein and Fermi-Dirac statistics.

PH 533. ADVANCED ELECTROMAGNETIC THEORY.
Classical electrodynamics and radiation theory.

ROBOTICS ENGINEERING

RBE 1001. INTRODUCTION TO ROBOTICS (FORMERLY ES 2201).
Cat. I
Multidisciplinary introduction to robotics, involving concepts from the fields of electrical engineering, mechanical engineering and computer science. Topics covered include sensor performance and integration, electric and pneumatic actuators, power transmission, materials and static force analysis, controls and programmable embedded computer systems, system integration and robotic applications. Laboratory sessions consist of hands-on exercises and team projects where students design and build mobile robots.
Undergraduate credit may not be earned for both this course and for ES 2201.
Recommended background: mechanics (PH 1110/PH 1111).

RBE 2001. UNIFIED ROBOTICS I.
Cat. I
First of a four-course sequence introducing foundational theory and practice of robotics engineering from the fields of computer science, electrical engineering and mechanical engineering. The focus of this course is the effective conversion of electrical power to mechanical power, and power transmission for purposes of locomotion, and of payload manipulation and delivery. Concepts of energy, power and kinematics will be applied. Concepts from statics such as force, moments and friction will be applied to determine power system requirements and structural requirements. Simple dynamics relating to inertia and the equations of motion of rigid bodies will be considered. Power control and modulation methods will be introduced through software control of existing embedded processors and power electronics. The necessary programming concepts and interaction with simulators and Integrated Development Environments will be introduced. Laboratory sessions consist of hands-on exercises and team projects where students design and build robots and related sub-systems.
Recommended background: ES 2201/RBE 1001, ES 2501 (can be taken concurrently), ECE 2022 and PH 1120 or PH 1121.

RBE 2002. UNIFIED ROBOTICS II.
Cat. I
Second of a four-course sequence introducing foundational theory and practice of robotics engineering from the fields of computer science, electrical engineering and mechanical engineering. The focus of this course is interaction with the environment through sensors, feedback and decision processes. Concepts of stress and strain as related to sensing of force, and principles of operation and interface methods for electronic transducers of strain, light, proximity and angle will be presented. Basic feedback mechanisms for mechanical systems will be implemented via electronic circuits and software mechanisms. The necessary software concepts will be introduced for modular design and implementation of decision algorithms and finite state machines. Laboratory sessions consist of hands-on exercises and team projects where students design and build robots and related sub-systems.
Recommended background: ES 2201/RBE 1001, ES 2501 (can be taken concurrently), ECE 2022 and PH 1120 or PH 1121.

RBE 3001. UNIFIED ROBOTICS III.
Cat. I
Third of a four-course sequence introducing foundational theory and practice of robotics engineering from the fields of computer science, electrical engineering and mechanical engineering. The focus of this course is actuator design, embedded computing and complex response processes. Concepts of dynamic response as relates to vibration and motion planning will be presented. The principles of operation and interface methods various actuators will be discussed, including pneumatic, magnetic, piezoelectric, linear, stepper, etc. Complex feedback mechanisms will be implemented using software executing in an embedded system. The necessary concepts for real-time processor programming, re-entrant code and interrupt signaling will be introduced. Laboratory sessions will culminate in the construction of a multi-module robotic system that exemplifies methods introduced during this course.
Recommended background: RBE 2002, ECE 2801, CS 2102, MA 2051, and MA 2071.
ECON 1110. INTRODUCTORY MICROECONOMICS.

Cat. I

This course is designed to acquaint students with the ways in which macroeconomic variables such as national income, employment and the general level of prices are determined in an economic system. It also includes a study of how the techniques of monetary policy and fiscal policy attempt to achieve stability in the general price level and growth in national income and employment. The problems of achieving these national goals (simultaneously) are also analyzed. The course stresses economic issues in public policy and international trade.

ECON 1120. INTRODUCTORY MACROECONOMICS.

Cat. I

This course focuses upon the implications of reliance upon markets for the allocation of resources in a society, at the household, firm, and community level. Outcomes of current market systems are examined in terms of the efficient use of natural and other economic resources, as well as their impact upon the environment, fairness, and social welfare. Special interest in these analyses is the role of prices in the determination of what commodities are produced, their means of production, and distribution among households. In cases where current market outcomes have features subject to widespread criticism, such as the presence of excessive pollution, risk, discrimination, and poverty, the analysis is extended to suggest economic solutions. There are no prerequisites for the course.

ECON 1130. INTRODUCTION TO ECONOMETRIC MODELING.

ISP Only

The purpose of this course is to provide students with an introduction to econometric modeling as it is applied in economics and to illustrate how it can be used in harmony with, or as an alternative to, system dynamics modeling. The first quarter of the course is devoted to discussing the methodological similarities and differences between econometric and system dynamics modeling, acquainting students with both the primary (survey instruments and controlled experiments) and secondary (government agencies and NGOs) sources of economic and social science data, and reviewing the basics of descriptive and inferential statistics. The remaining three quarters of the course are devoted to an examination of the assumptions that underlie the ordinary least squares model, the problems that occur when these assumptions are violated, and the methods that are available for correcting these problems. Throughout this process, the use of socioeconomic data, and the roles of economic theory and econometric software in modeling are emphasized. The course concludes with a presentation of how the econometric modeling can be used to complement system dynamics modeling.

ECON 2110. INTERMEDIATE MICROECONOMICS.

Cat. II

The topics addressed in this course are similar to those covered in ECON 1110 (Introductory Microeconomics) but the treatment proceeds in a more rigorous and theoretical fashion to provide a firm platform for students majoring in Economics or Management, or those having a strong interest in economics. Mathematics at a level comparable to that taught in MA 1021-MA 1024 is frequently applied to lend precision to the analysis. The course rigorously develops the microeconomic foundations of the theory of the firm, the theory of the consumer, the theory of markets, and the conditions required for efficiency in economic systems.

Recommended background: ECON 1110.

This course will be offered in 2011-12 and in alternating years thereafter.

ECON 2117. ENVIRONMENTAL ECONOMICS.

Cat. II

This course investigates the effects of human activity upon the environment as well as the effect of the environment on human well-being. It pays special attention to the impact of production and consumption of material goods upon the quantity and quality of environmental goods. The analysis focuses on the challenges presented in mixed economies in which markets are combined with government intervention to manage pollution and scarcity. The course stresses efforts to measure the costs and benefits of improving environmental conditions and evaluates current and potential policies in terms of the costs of the environmental improvements they may yield. Attention is also paid to the special difficulties which arise when the impacts of pollution spill across traditional political boundaries. Recommended background: ECON 1110.

This course will be offered in 2012-13 and in alternating years thereafter.

ECON 2120. INTERMEDIATE MACROECONOMICS.

Cat. II

This course is an advanced treatment of macroeconomic theory well suited for students majoring in Economics or Management, or others with a strong interest in economics. The topics addressed in ECON 2120 are similar to those covered in ECON 1120, however the presentation of the material will proceed in a more rigorous and theoretical fashion.

Recommended background: ECON 1110.

This course will be offered in 2012-13 and in alternating years thereafter.

ECON 2125. DEVELOPMENT ECONOMICS.

Cat. II

This course is a general introduction to the field of development economics. The focus is on ways in which a developing country can increase its productive capacity, both agricultural and industrial, in order to achieve sustained economic growth. The course proceeds by first examining how economic growth and economic development are measured and how the various nations of the world
compare according to well-known social and economic indicators. Theories of economic growth and theories of economic development are then examined, as are the various social and cultural structures that are thought to influence economic progress. The inputs to economic growth and development (land, labor, capital, entrepreneurial ability, education, technical change), and the possible distributions of income and levels of employment that result from their use, is considered next. Domestic economic problems and policies such as development planning, the choice of sectorial policies, the choice of monetary and fiscal policies, rapid population growth, and urbanization and urban economic development are then examined. The course concludes with a consideration of international problems and policies such as import substitution and export promotion, foreign debt, foreign investment, and the role of international firms. In conjunction with a traditional presentation of the above topics, the course curriculum will include the use of computer simulation models and games. These materials have been formulated with a simulation technique, system dynamics, that has its origins in control engineering and the theory of servomechanisms. As a result, students will find them complementary to their work in engineering and science. In addition, the various development theories and simulation and gaming results will be related, where possible, to specific developing nations where WPI has on-going project activities (e.g., Costa Rica and Thailand). This course is recommended for those students wishing to do an IQP or MQP in a developing nation.

Recommended background: ECON 1120.
This course will be offered in 2011-12 and in alternating years thereafter.

**ECON 2135. INFORMATION ECONOMICS AND POLICY.**
*Cat. II*
This course provides an introduction to the economics, business strategies, and regulatory and legal aspects of telecommunications markets. The analysis of complex interactions between technology, Federal and state government policies, copyright, legislation, and forces driving supply and demand is performed using Economic and Industrial Organization theories combined with computer simulation techniques. Topics include, among others: the economics of telephony services, cable TV, satellite communication, spectrum auctions, WLAN, and peer-to-peer file sharing. Special attention will be paid to the analysis of the latest regulatory and legal developments in the telecommunication industry.

Recommended background: ECON 1110 or ECON 2110.
This course will be offered in 2011-12 and in alternating years thereafter.

**ECON 2155. EXPERIMENTAL ECONOMICS.**
*Cat. II*
Experimental economics is a set of methods for testing hypotheses about behavior. Traditional economic analysis using naturally occurring data is often confounded by the complexities of the real world. Economic experiments, on the other hand, give researchers the control required for isolating behaviors of interest. As such, economic experiments can be useful tools for testing existing theories and establishing empirical regularities assisting in the development of new theories. In this course, we cover the basic principles of experimental design. We also study a number of classic experiments, on topics ranging from the efficiency of markets to decision-making under uncertainty and behavioral game theory. Students will participate in mock experiments and will begin putting their new skills into practice by designing their own experiments, which may serve as the basis for IQP/MQP. If time permits, we will discuss some of the basic methods for analyzing experimental data, which presents challenges somewhat different from naturally occurring data due to small sample sizes.

Recommended Background: ECON 1110
This course will be offered in 2011-12 and in alternating years thereafter.

**ENVIRONMENTAL STUDIES (ENV)***

**ENV 1100. INTRODUCTION TO ENVIRONMENTAL STUDIES.**
*Cat. I*
The study of environmental problems and their solutions requires an interdisciplinary approach. This course will examine current environmental issues from the intersection of several key disciplines including: environmental philosophy and history, environmental policy, and science. The course will develop these different approaches for analyzing environmental problems, explore the tensions between them, and present a framework for integrating them. Topics such as environmental justice, developing nations, globalization, and climate change policy will be explored.

**ENV 2200. ENVIRONMENTAL STUDIES IN THE VARIOUS DISCIPLINES.**
*Cat. II*
Many disciplines contribute to the study of the environment. This course presents an overview of the approach taken by some of these disciplines, which may include biology, chemistry, engineering, geography, public policy, philosophy, history, and economics, and how they interact to help us understand environmental problems and solutions. Through an examination of the assumptions made and lenses used by different disciplines students will gain insight into how different actors and institutions frame environmental issues and how to overcome barriers to communication between disciplines. To ground the exploration of these disciplines contemporary environmental issues and policy programs will be explored.

Recommended background: ENV 1100.
This course will be offered in 2012-13 and in alternating years thereafter.

**ENV 2400. ENVIRONMENTAL PROBLEMS AND HUMAN BEHAVIOR.**
*Cat. II*
This course examines how people think about and behave toward the environment. Environmental problems can ultimately be attributed to the environmental decisions and actions of human beings. These behaviors can in turn be understood as resulting from the nature and limitations of the human mind and the social context in which behavior takes place. Knowledge of the root causes of environmentally harmful behavior is essential for designing effective solutions to environmental problems. The goals of the course are (1) to provide students with the basic social science knowledge needed to understand and evaluate the behavioral aspects of such important environmental problems as air and water pollution, global warming, ozone depletion, preserving biological diversity, and hazardous waste and (2) to help students identify and improve shortcomings in their knowledge and decisions related to the environment. Topics will include, but not be limited to: environmental problems as “tragedies of the commons”; public understanding of global warming and global climate modeling; folk biology; risk perception; intelligent criticism of environmental claims; making effective environmental choices; strategies for promoting pro-environmental behavior; and human ability to model and manage the global environmental future.

Recommended background: ENV 1100.
Suggested background: PSY 1400, PSY 1401, or PSY 1402.
Students may not receive credit for both PSY 2405 and ENV 2400.
This course will be offered in 2011-12 and in alternate years thereafter.

**ENV 4400. SENIOR SEMINAR IN ENVIRONMENTAL STUDIES.**
*Cat. I*
This course is intended for Environmental Studies majors. The course is designed to integrate each student’s educational experience (e.g., core environmental courses, environmental electives, and environmental projects) in a capstone seminar in Environmental Studies. Through seminar discussions and writing assignments students will critically reflect on what they learned in their previous courses and project experiences. In teams, students will prepare a final capstone paper and presentation that critically engages their educational experience in environmental studies and anticipates how their courses and experiences will translate into their future personal and professional environmental experiences.

Recommended background: ENV 1100, ENV 2200 or ENV 2400, completion or concurrent enrollment in IQP and MQP.

**POLITICAL SCIENCE, GOVERNMENT AND LAW (GOV)***

**GOV 1301. U.S. GOVERNMENT.**
*Cat. I*
This course is an introduction to the fundamental principles, institutions, and processes of the constitutional democracy of the United States. It examines the formal structure of the Federal system of government, including Congress, the presidency, the judiciary, and the various departments, agencies, and commissions which comprise the executive branch. Emphasis is placed on the relationships among Federal, state and local governments in the formulation and administration of domestic policies, and on the interactions among interest groups, elected officials and the public at large with administrators in the policy process. The various topics covered in the survey are linked by consideration of fiscal and budgetary issues, executive management, legislative oversight, administrative discretion, policy analysis and evaluation and democratic accountability. May be included in certain Humanities and Arts programs. See page 27.
This course is an introduction to law and the role courts play in society. The course examines the structure of judicial systems, the nature of civil and criminal law, police practice in the enforcement of criminal law, and the responsibilities of judges, attorneys and prosecutors. Additional topics for discussion include the interpretation of precedent and statute in a common law system and how judicial discretion enables interest groups to use courts for social change. The student is expected to complete the course with an understanding of how courts exercise and thereby control the power of the state. As such, courts function as political actors in a complex system of governance. It is recommended that students complete this course before enrolling in GOV 2310, Constitutional Law.

This course will be offered in 2011-12 and in alternating years thereafter.

GOV 1320. TOPICS IN INTERNATIONAL POLITICS.
Cat. II
GOV 1320 is a survey course designed to introduce students to the basic concepts of international relations: power and influence, nations and states, sovereignty and law. These concepts will be explored through the study of issues such as diplomacy and its uses, theories of collective security and conflict, and international order and development. The study of international organizations such as the UN, the European Union or the Organization of American States will also supplement the students’ understanding of the basic concepts. The course may also include comparative political analysis of states or regions. It is designed to provide the basic groundwork materials for students who wish to complete IQPs on topics that involve international relations or comparative political systems.

This course will be offered in 2012-13 and in alternating years thereafter.

GOV 2302. SCIENCE-TECHNOLOGY POLICY.
Cat. II
This course is an examination of the relationship between science-technology and government. It reviews the history of public policy for science and technology, theories and opinions about the proper role of government and several current issues on the national political agenda. Examples of these issues include genetic engineering, the environment and engineering education. It also examines the formation of science policy, the politics of science and technology, the science bureaucracy, enduring controversies such as public participation in scientific debates, the most effective means for supporting research, and the regulation of technology. Throughout the course we will pay particular attention to the fundamental theme: the tension between government demands for accountability and the scientific community’s commitment to autonomy and self-regulation.

Recommended background: GOV 1301 or GOV 1303.

This course will be offered in 2012-13 and in alternating years thereafter.

GOV 2304. GOVERNMENTAL DECISION MAKING AND ADMINISTRATIVE LAW.
Cat. II
The course addresses the role of technical expertise in political decision making. Politicians and public administrators rely on the expert knowledge of scientists and engineers to “bring reason” to otherwise political decisions. The course specifically addresses decision making in the administrative context including the value of expert knowledge, circumstances of inadequate information and the need to accommodate the political agenda. The context for the discussion will be the problems of regulated industries (for example, energy or those industries subject to environmental regulation). Legal review of administrative decision making will also be addressed.

Recommended background: GOV 1301 or GOV 1303 or GOV 2310.

This course will be offered in 2011-12 and in alternating years thereafter.

GOV 2310. CONSTITUTIONAL LAW: FOUNDATIONS OF GOVERNMENT.
Cat. II
Constitutional Law is the study of Supreme Court decisions interpreting the U. S. Constitution. The Foundations course focuses on the powers of the Congress, the Presidency and the Judicial Branch, especially the Supreme Court’s understanding of its own power. These cases reveal, in particular, the evolution of Federal power with the development of a national economy and the shifting balance of power among the three branches of government. Issues of state power in a federal system are also addressed. Lastly, these materials are examined in the context of the great debates regarding how judges interpret the Constitution. How are the words and intent of the Founders applicable to the legal and political conflicts of the twenty-first century?

This course will be offered in 2012-13 and in alternating years thereafter.

GOV 2311. ENVIRONMENTAL POLICY AND LAW.
Cat. I
This course deals with environmental law as it relates to people, pollution and land use in our society. A case method approach will be used to illustrate how the courts and legislators have dealt with these social-legal problems. The course is designed to have the student consider: 1) the legal framework within which environmental law operates; 2) the governmental institutions involved in the formulation, interpretation and application of environmental law; 3) the nature of the legal procedures and substantive principles currently being invoked to resolve environmental problems; 4) the types of hazards to the environment presently subject to legal constraints; 5) the impact that the mandates of environmental law have had, and will have, on personal liberties and property rights; 6) the role individuals and groups can play within the context of our legal system to protect and improve man's terrestrial habitat and the earth’s atmosphere; and 7) some methods and sources for legal research that they may use on their own.

Recommended background: GOV 1303 or GOV 1310.

GOV 2312. INTERNATIONAL ENVIRONMENTAL POLICY.
Cat. II
Environmental issues present some of the major international problems and opportunities facing the world today. Worst-case scenarios envision irrevocable degradation of the earth’s natural systems, but virtually every analysis sees the need for major change worldwide to cope with problems such as global warming, deforestation, ozone layer depletion, loss of biodiversity, and population growth, not to mention exponential increases in “conventional” pollutants in newly industrialized countries. The global environment issues represent a “second-generation” of environmental policy in which the focus of concern has moved from national regulations to international law and institutions. In addition, the environment has emerged as a major aspect of international trade, conditioning corporate investment and accounting for some $200 billion in sales of pollution control equipment in 1991. Exploration of the genesis and implications of these phenomena is the focus of the course. TOPICALLY, the material begins with an overview of global environmental problems, drawing on literature from large-scale global modeling as well as particular analyses of the problems mentioned above. Approximately half the course focuses on international laws and institutions, including multilateral treaties (e.g., the Montreal Protocol limiting CFC use, ocean dumping, biodiversity), international institutions (UNEP, the Rio Convention, the OECD) and private initiatives (International standards organizations, ICOLP (Industry Committee for Ozone Layer Protection), etc.). In addition, US policy toward global environmental issues will be compared with that in Japan, Europe and developing countries, from which it differs significantly. Students will design and undertake term projects that address particular issues in detail in an interdisciplinary manner.

Recommended background: GOV 1303.

This course will be offered in 2011-12 and in alternating years thereafter.

GOV 2313. INTELLECTUAL PROPERTY LAW.
Cat. II
Intellectual property includes ideas, and the works of inventors, authors, composers and other creative people. Patents, copyrights and trademarks establish legal rights in intellectual property. Alternatively, control over the use of an idea might be maintained by treating it as a trade secret. In these ways, the ideas of inventors and creators are protected and others are prohibited from appropriating the ideas and creative works of others. This course addresses the concept of intellectual property and the public policies that support the law of patent, copyright and trademark. Subjects include the process of obtaining
PSY 1400. INTRODUCTION TO PSYCHOLOGICAL SCIENCE.
Cat. I
Psychological science is the experimental study of human thought and behavior. Its goal is to contribute to human welfare by developing an understanding of why people do what they do. Experimental psychologists study the entire range of human experience, from infancy until death. From the most abnormal behavior to the most mundane, from the behavior of genes to the actions of nations. This course offers a broad introduction to important theories, empirical findings, and applications of research in psychological science. Topics will include: use of the scientific method in psychology; learning, sensation and perception, memory, consciousness, language, intelligence and thinking, life-span development, social cognition and behavior, motivation and emotion, and the nature and treatment of psychological disorders.

PSY 1401. COGNITIVE PSYCHOLOGY.
Cat. I
This course is concerned with understanding and explaining the mental processes and strategies underlying human behavior. The ways in which sensory input is transformed, reduced, elaborated, stored, and recovered will be examined in order to develop a picture of the human mind as an active processor of information. Topics will include perception, memory, problem-solving, judgment and decision making, human-computer interaction, and artificial intelligence. Special attention will be paid to defining the limitations of the human cognitive system. Students will undertake a project which employs one of the experimental techniques of cognitive psychology to collect and analyze data on a topic of their own choosing.
Suggested background: PSY 1400.

PSY 1402. SOCIAL PSYCHOLOGY.
Cat. I
Social psychology is concerned with how people think about, feel for, and act toward other people. Social psychologists study how people interact by focusing on the individual (not society as a whole) as the unit of analysis, by emphasizing the effect on the individual of the situation or circumstances in which behavior occurs, and by acquiring knowledge through empirical scientific investigation. This course will examine the cause of human behavior in a variety of domains of social life. Topics will include, but not be limited to, person perception, attitude formation and change, interpersonal attraction, stereotyping and prejudice, and small group behavior. Special attention will be given to applied topics: How can the research methods of social psychology be used to help solve social problems? Students will work together in small groups to explore in depth topics in social psychology of their own choosing. May be included in certain Humanities and Arts programs. See page 27.
Suggested background: PSY 1400.

PSY 1504. STRATEGIES FOR IMPROVING COGNITIVE SKILLS.
Cat. I
This course will focus on current issues in technological education and address the responsibilities and liability of internet service providers are also discussed. Additional policies studied include attempts to control Internet content and enforce international judgments (resulting from e-commerce or cyber-crime) by foreign states and/or international organizations. Students are expected to integrate knowledge of technology with law, politics, economics and international affairs.
This course will be offered in 2012-13 and in alternating years thereafter.

GOV 2320. CONSTITUTIONAL LAW: CIVIL RIGHTS AND LIBERTIES.
Cat. II
Civil Rights and Liberties examines decisions of the Supreme Court which interpret the Bill of Rights and the Equal Protection Clause of the 14th Amendment. The court's decisions expand the content and meaning of our rights to speak, publish, practice religion, and be free from state interference in those activities. Privacy rights broadly, the right to be free from unreasonable search and seizure, and due process rights for criminal suspects are also addressed. Finally, rights to be free from discrimination based on race, religion, ethnicity, gender and sexual orientation are examined in the context of equal protection law.
Students completing this course will receive credit toward the Minor in Law and Technology among the courses satisfying the requirement in "legal fundamentals."
This course will be offered in 2011-12 and in alternating years thereafter.

PSYCHOLOGY (PSY)
PSY 2406. CROSS-CULTURAL PSYCHOLOGY: HUMAN BEHAVIOR IN GLOBAL PERSPECTIVE.

Cat. II
This course is an introduction to the study of the ways in which social and cultural forces shape human behavior. Cross-Cultural psychology takes a global perspective of human behavior that acknowledges both the uniqueness and interdependence of peoples of the world. Traditional topics of psychology (learning, cognition, personality development) as well as topics central to social psychology, such as intergroup relations and the impact of changing cultural settings, will be explored. Cultural influences on technology development and transfer, as they relate to and impact upon individual behavior, will also be investigated. Students preparing to work at international project centers, International Scholars, and students interested in the global aspects of science and technology will find the material presented in this course especially useful.
Recommended background: PSY 1400 or PSY 1402.
This course will be offered in 2012-13 and in alternating years thereafter.

PSY 2407. PSYCHOLOGY OF GENDER.

Cat. II
This course will provide an overview of the psychological study of gender and will utilize psychological research and theory to examine the influence of gender on the lives of men and women. This course will examine questions such as: What does it mean to be male or female in our society and other societies? How do our conceptions of gender develop over our life span? How does our social world (e.g., culture, religion, media) play a role in our construction of gender? And What are the psychological and behavioral differences and similarities between men and women?
Recommended background: PSY 1400 or PSY 1402.
This course will be offered in 2011-12 and in alternating years thereafter.

SYSTEM DYNAMICS (SD)

SD 1510. INTRODUCTION TO SYSTEM DYNAMICS MODELING.

Cat. I
The goal of this course is to provide students with an introduction to the field of system dynamics computer simulation modeling. The course begins with the history of system dynamics and the study of why policy makers can benefit from its use. Next, students systematically examine the various types of dynamic behavior that socioeconomic systems exhibit and learn to identify and model the underling nonlinear stock-flow-feedback loop structures that cause them. The course concludes with an examination of a set of well-known system dynamics models that have been created to address a variety of socioeconomic problems. Emphasis is placed on how the system dynamics modeling process is used to test proposed policy changes and how the implementation of model-based results can improve the behavior of socioeconomic systems.

SD 1520. SYSTEM DYNAMICS MODELING.

Cat. I
The purpose of this course is to prepare students to produce original system dynamics computer simulation models of economic and social systems. Models of this type can be used to examine the possible impacts of policy changes and technological innovations on socioeconomic systems. The curriculum in this course is divided into three distinct parts. First, a detailed examination of the steps of the system dynamics modeling process: problem identification (including data collection), feedback structure conceptualization, model formulation, model testing and analysis, model documentation and presentation, and policy implementation. Second, a survey of the “nuts and bolts” of continuous simulation modeling: information and material delays, time constants, the use of noise and numerical integration techniques, control theory heuristics, and software details (both simulation and model presentation and documentation software). Third, a step-by-step, in-class production of a model, involving the construction, testing, and assembly of subsectors. Students will be required to complete modeling assignments working in groups and take in-class quizzes on modeling issues.
Recommended background: SD1510, or permission of instructor.

SD 2530. ADVANCED TOPICS IN SYSTEM DYNAMICS MODELING.

ISP Only
This course will focus on advanced issues and topics in system dynamics computer simulation modeling. A variety of options for dealing with complexity through the development of models of large-scale systems and the partitioning of complex problems will be discussed. Topics will include an extended discussion of model analysis, the use of summary statistics and sensitivity measures, the model validation process, and policy design. The application of system Dynamics to theory building and social policy are also reviewed. Complex nonlinear dynamics and the chaotic behavior of systems will be discussed. Students will be assigned group exercises centering on model analysis and policy design.
Recommended background: SD 1520.

SD 3550. SYSTEM DYNAMICS SEMINAR.

ISP Only
This special topics course is designed primarily for system dynamics majors and students presently engaged in planning system dynamics projects. The course will be conducted as a research seminar, with many sessions being reserved for student presentations. Classical system dynamics models will be replicated and discussed. Students will read, evaluate, and report on research papers representing the latest developments in the field of system dynamics. They will also complete a term project that addresses a specific problem using the system dynamics method.
Recommended background: SD 1520 and SD 2530.

SOCIOLOGY (SOC)

SOC 1202. INTRODUCTION TO SOCIOLOGY AND CULTURAL DIVERSITY.

Cat. I
The Introduction to Sociology and Cultural Diversity is a Macro-Sociology course on modernization that incorporates a systematic comparison of one of the most and one of the least modernized regions of the World: Europe and the Middle East. However, the focus is on concepts used to describe how the social structure, culture and nature of community were affected by this massive social transition, and how to do qualitative comparative research at the level of whole societies. The field of sociology was created in the 19th century to try to understand the social changes and trends (ranging from social differentiation and demographic transition to the emergence of bureaucracy and secularization) that were sweeping Europe as the area industrialized. Trying to understand what new kind of society was being born amidst the ruins of the old order was the task of Sociology, the new science of society.
The course is designed to give students planning to go to Europe to do project work a chance to learn about the country they will be visiting, while giving everyone a chance to learn something about the Middle East.

GENERAL SOCIAL SCIENCE (SS)

SS/ID 2050. SOCIAL SCIENCE RESEARCH FOR THE IQP.

Cat. I
This course is open to students accepted to off-campus IQP centers and programs. The course introduces students to research design, methods for social science research, and analysis. It also provides practice in specific research and field skills using the project topics students have selected in conjunction with sponsoring agencies. Students learn to develop social science hypotheses based upon literature reviews in their topic areas and apply concepts drawn from social psychology, anthropology, sociology, economics and other areas as appropriate.
Students make presentations, write an organized project proposal, and develop a communication model for reporting their project findings.

SS 2400. METHODS, MODELING, AND ANALYSIS IN SOCIAL SCIENCE.

Cat. II
What is the process by which a hypothesis about human behavior gets supported or rejected? This course represents a review of the methodological tools of social and behavioral science. Topics to be covered include experimental design and ethical issues specific to behavioral research with human subjects, the use of statistical and simulation modeling in the interpretation of behavioral phenomena, and methods for statistical inference in compiling evidence for or against a hypothesis.
Recommended background: PSY 1400 and either PSY 1401 or PSY 1402.
This course will be offered in 2011-12 and in alternate years thereafter.
SD 552. SYSTEM DYNAMICS FOR INSIGHT.
The objective of this course is to help students appreciate and master system dynamics’ unique way of using of computer simulation models. The course provides tools and approaches for building and learning from models. The course covers the use of molecules of system dynamics structure to increase model building speed and reliability. In addition, the course covers recently developed eigenvalue-based techniques for analyzing models as well as more traditional approaches. Pre-requisites: SD 550 and SD 551

SD 553. MODEL ANALYSIS AND EVALUATION TECHNIQUES.
This course focuses on analysis of models rather than conceptualization and model development. It provides techniques for exercising models, improving their quality and gaining added insights into what models have to say about a problem. Five major topics are covered: Use of subscripts, achieving and testing for robustness, use of numerical data, sensitivity analysis, and optimization/ calibration of models. The Subscripts discussion provides techniques for dealing with detail complexity by changing model equations but not adding additional feedback structure. Robust models are achieved by using good individual equation formulations and making sure that they work together well though automated behavioral experiments. Data, especially time series data, are fundamental to finding and fixing shortcomings in model formulations. Sensitivity simulations expose the full range of behavior that a model can exhibit. Finally, the biggest section, dealing with optimization and calibration of models develops techniques for both testing models against data and developing policies to achieve specified goals. Though a number of statistical issues are touched upon during the course, only a basic knowledge of statistics and statistical hypothesis testing is required. Pre-requisites: SD 550 and SD 551, or permission of the instructor

SD 554. REAL WORLD SYSTEM DYNAMICS.
In this course students tackle real-world issues working with real managers on their most pressing concerns. Many students choose to work on issues in their own organizations. Other students have select from a number of proposals put forward by managers from a variety of companies seeking a system dynamics approach to an important issue. Students experience the joys (and frustrations) of helping people figure out how to better manage their organizations via system dynamics. Accordingly the course covers two important areas: Consulting (i.e. helping managers) and the system dynamics standard method - a sequence of steps leading from a fuzzy “issue area” through increasing clarity and ultimately to solution recommendations. The course provides clear project pacing and lots of support from the instructors and fellow students. It is recommend that students take this course toward the end of their system dynamics coursework as it provides a natural transition from course work to system dynamics practice. Pre-requisites: SD 550 and SD 551

SD 556. STRATEGIC MODELING AND BUSINESS DYNAMICS.
The performance of firms and industries over time rarely unfolds in the way management teams expect or intend. The purpose of strategic modeling and business dynamics is to investigate dynamic complexity by better understanding how the parts of an enterprise operate, fit together and interact. By modeling and simulating the relationships among the parts we can anticipate potential problems, avoid strategic pitfalls and take steps to improve performance. We study a variety of business applications covering topics such as cyclicality in manufacturing, market growth and capital investment. The models are deliberately small and concise so their structure and formulations can be presented in full and used to illustrate principles of model conceptualization, equation formulation and simulation analysis. We also review some larger models that arose from real-world applications including airlines, the oil industry, the chemicals industry and fast moving consumer goods. Students work with selected business policy problems based on generic structures discussed in the lessons. Prerequisite: SD550 System Dynamics Foundation: Managing Complexity
SD 557. LATENT STRUCTURES, UNINTENDED CONSEQUENCES, AND PUBLIC POLICY.
This course addresses policy resilience and unintended consequences arising out of actions that are not cognizant of the latent structure causing the problem. An attempt is made to identify the generic systems describing such latent structures. The latent structures discussed include a selection from capacity constraining and capacity enabling systems, resource allocation, and economic cycles of various periodicities. Problems discussed in lessons include pests, gang violence, terrorism, political instability, professional competence in organizations, urban decay, and economic growth and recessions. Students work with selected public policy problems relevant to the generic latent structures discussed in the course.
Pre-requisites: SD550 System Dynamics Foundation: Managing Complexity, SD551 Modeling and Experimental Analysis of Complex Problems

SD 558. INTRODUCTION TO AGENT-BASED MODELING.
The purpose of this course is to provide students with an introduction to the field of agent-based computer simulation modeling in the social sciences. The course begins with an outline of the history of the field, as well as of the similarities and differences between agent-based computer simulation modeling and system dynamics computer simulation modeling. An important goal of the course is to provide students with guidelines for deciding when it is preferable to apply agent-based modeling, and when it is preferable to apply system dynamics modeling, to a particular problem. Through a series of example models and homework exercises students are introduced to the software that is used in the course. Generally speaking, as the course progresses students will be introduced to increasingly complicated agent-based models and exercises so that their modeling skills will grow. The goal is to increase students’ modeling skills so that they will eventually be able to create their own agent-based models from scratch. The remainder of the course is devoted to examining models of socioeconomic phenomena that reside within two broad categories of agent-based models: cellular automata models and multi-agent models. Along the way the cross-category, cross-disciplinary, principles of agent-based modeling (microlevel agents following simple rules leading to macro-level complexity, adaptation, evolving structure, emergence, non-ergodicity) are emphasized.

SD 560. STRATEGY DYNAMICS.
This course provides a rigorous set of frameworks for designing a practical path to improve performance, both in business and non-commercial organisations. The method builds on existing strategy concepts, but moves substantially beyond them, by using the system dynamics method to understand and direct performance through time. Topics covered include: Strategy; performance and resources; Resources and accumulation; The ‘Strategic Architecture’; Resource Development; Rivalry and the Dynamics of Competition; Strategy, Policy and Information Feedback; Resource Attributes; Intangible Resources; Strategy, Capabilities and Organization; Industry Dynamics and Scenarios. Case studies and models are assigned to students for analysis.

SD 561. ENVIRONMENTAL DYNAMICS.
Environmental Dynamics introduces the system dynamics students to the application in environmental systems. The course materials include the book Modeling the Environment, a supporting website, lectures and the corresponding power point files. Students learn system dynamics with examples implemented with the Stella software. The course includes a variety of small models and case applications to water shed management, salmon restoration, and incentives for electric vehicles to reduce urban air pollution. The students conclude the course with a class project to improve one of the models from the book Modeling the Environment. The improvements may be implemented with either the Stella or the Vensim software. Pre-requisites: SD 550

SD 562. PROJECT DYNAMICS.
This course will introduce students to the fundamental dynamics that drive project performance, including the rework cycle, feedback effects, and inter-phase “knock-on” effects. Topics covered include dynamic project problems and their causes: the rework cycle and feedback effects, knock-on effects between project phases; Modeling the dynamics: feedback effects, schedule pressure and staffing, schedule changes, inter-phase dependencies and precedence; Strategic Project management: Project Planning, Project Preparation, Risk management, Project adaptation and execution. Case project learning: Multi-project issues. A simple project model will be created, and used in assignments to illustrate the principles of “strategic project management.” Case examples of different applications will be discussed. Pre-requisites: SD 550

SD 565. MACROECONOMIC DYNAMICS.
There are three parts to this course. The first acquaints a student with dynamic macroeconomic data and the stylized facts seen in most macroeconomic systems. Characteristics of the data related to economic growth, economic cycles, and the interactions between economic growth and economic cycles that are seen as particularly important when viewed through the lens of system dynamics, will be emphasized. The second acquaints a student with the basics of macroeconomic growth and business cycle theory. This is accomplished by presenting well-known models of economic growth and instability, from both the orthodox and heterodox perspectives, via system dynamics. The third part attempts to enhance a student’s ability to build and critique dynamic macroeconomic models by addressing such topics as the translation of difference and differential equation models into their equivalent system dynamics representation, fitting system dynamics models to macroeconomic data, and evaluating (formally and informally) a model’s validity for the purpose of theory selection. Pre-requisites: SD 550

SS 590. SPECIAL TOPICS IN SYSTEM DYNAMICS.
(credit as specified)
Individual or group studies on any topic relating to social science and policy studies selected by the student and approved by the faculty member who supervises the work.